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Exploring the nature of Grade 7 science learners' untutored ability in argumentation

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A research report submitted to the Faculty of Humanities, University of the Witwatersrand, in partial fulfillment of the requirements for the degree of Masters of Education.

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I declare that this research proposal is my own work and no part of it has been copied from another source *(unless indicated as a quote*). All phrases, sentences and paragraphs taken directly from other works have been cited and the reference recorded in a full reference list.

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Thulani Mkhokheli Moyo

14th day of March 2016

ABSTRACT

Argumentation is viewed as an important pedagogical tool that is central to the teaching and learning of science. Research has shown argumentation as one of the pedagogical practices that promote meaningful learner talk and engagement. In South Africa, most such research has been carried out in high schools and universities on tutored ability in argumentation. There is no research on untutored learner ability in argumentation in primary school science. This study sought to address this gap by determining untutored learner argumentation in science in a Gauteng primary school. I wanted to establish whether and how untutored learners argue and the nature of their arguments. I also wanted to examine the evidence that they give to support assertions.

I observed learner interactions in my two Grade 7 science classes through small group discussions and whole class discussions. All the participants were from a public primary school in Gauteng. These learners were untutored (had not been taught) in argumentation, but as their teacher, I had been exposed to argumentation through participation in a masters course. I used qualitative research methodology and drew from Toulmin's Argument Pattern (TAP) to determine the construction of arguments during the science lessons. I used an analytic frame work by Erduran, Simon and Osborne (2004) which helps to categorize the various components of an argument into different levels.

My findings indicated that learners who are untutored in argumentation are able to formulate arguments. Literature has reported that untutored learners in high schools in South Africa present only level 2 arguments. In this study, Grade 7 learners who are untutored in argumentation were able to formulate level 3 arguments in some instances. The study further revealed that some of the learners were able to support their arguments using scientific evidence although most tended to be simple constructs consisting of only data and claims. The fact that they were taught by a teacher, who is tutored in argumentation, may have literature bearing on the learners' argument ability. Current work in South Africa has shown how untutored teachers do not argue: how untutored learners do not argue: how tutored teachers learn to argue and how tutored learners can learn to argue. What we do not know is how untutored learners argue if they have a tutored teacher. Further research might inform teacher education and classroom argumentation in constrained environments where learners are generally untutored as is the case in many South African classrooms.

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I want to extend my sincere thanks to my brother Mcedisi who always encouraged me simply by being the role model of excellence; who I aspire to become one day. To my parents, sisters and brothers, thank you for challenging me relentlessly to improve myself.

Lastly, I would like express my profound gratitude to my fellow students in the university, for their unwavering support.

DEDICATION

This work is dedicated to my family for their patience, love and support.

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CHAPTER 1
INTRODUCTION AND BACKGROUND
1.1 INTRODUCTION

According to Osborne (2010), knowledge transmission has remained a dominant practice in the teaching and learning of science. This is inconsistent with the current understanding in the science teaching and learning which views argument and debate as central to science learning. Argumentation and debate develop learners' ability to reason and argue scientifically. Through argumentation, learners get the opportunity to engage in discussions, present and critique ideas during science learning. Developing the ability to critique ideas using science evidence, helps learners acquire cognitive skills which eventually leads to a better understanding of science concepts. Of concern however, is that argument and debate are virtually absent from science education. In education research, argumentation has been used as a teaching strategy that helps learners develop scientific cognitive skills (Zohar & Nemet, 2002). Learner engagement is central in the learning and teaching of science, if the learners are to acquire and understand science knowledge appropriately.

The challenge in South Africa is that learners struggle to understand science, as shown by the poor performance in science examinations and various international tests continuously (Dempster & Reddy, 2007). One of the reasons for poor performance could be lack of engagement in science classes. Learners do not engage with science concepts well enough to enable them to have a good understanding. Osborne (2010) states that, deep within our cultural fabric, education is still seen as a process of transmission where knowledge is presented as a set of facts and transferred from the expert to the novice. Yet, learner engagement is very critical in the learning and teaching of science (Newton, Driver & Osborne, 2010), because it allows learners to make meaning of the concepts through interaction. Thus, argumentation is one of the strategies that can be used to foster active engagement of learners in the classroom. When learners engage during the learning process, they talk, argue and defend their views. This study seeks to determine if Grade 7 science learners who are untutored in argumentation, do argue, how they argue and support their claims during science lessons.

1.2 PROBLEM STATEMENT

The poor performance of Grade 7 learners in science examinations in my school suggests that learners experience challenges in understanding scientific concepts. Reddy (2005), observed that performance in mathematics and science is poor at all levels in the South African education system. The problem is the way learners are taught science concepts. Newton et al (2010) found out that the transmission model is still the dominant practice in science classrooms and yet it does not promote learner understanding of science concepts. There is a need for appropriate teaching and learning strategies in the science classrooms. Such strategies should allow learners an opportunity to engage with science concepts, think about them and construct arguments resulting in creation of meaning and new understandings. My study seeks to investigate the nature of Grade 7 learners' engagement in science lesson, to gain an insight on whether and how learners argue as they engage with science concepts.

1.3 RATIONALE

Science teaching attempts to introduce learners to the perspectives of scientists on the nature of scientific knowledge. This can be done through argumentation as a teaching and learning tool. According to research, there is developmental improvement in argumentation skills from the age of eight through early and middle adolescence (Kuhn, 1991). This suggests that argumentation should be used as a teaching strategy during initial stages of formal education. Most of the research on argumentation in South Africa has been carried out in universities and secondary schools where learners and teachers have been trained in argumentation. These are referred to as tutored teachers and learners. No research has been done on argumentation in the South African primary schools with tutored or untutored learners. I explored how primary school learners who are untutored in argumentation engage during science lessons to determine whether and how the untutored learners construct arguments and how they support their arguments.

1.4 THE AIM OF THE STUDY

The aim of the study is two-fold. Firstly, the study aims to understand the nature of arguments presented by Grade 7 science learners who are untutored in argumentation. By nature I mean the presence of argument components in the TAP which is the argument structure. By untutored I mean learners who have not been taught how to use argumentation during learning in science. Secondly, I want to determine the quality of arguments. By quality I mean how accurate the various components of the arguments are scientific. Thirdly, I want

to find out if learners use scientific evidence to support their arguments. The purpose of the investigation is to determine whether and how learners who are untutored in argumentation construct and support their arguments. The investigation will address the following three research questions:

Main question: What is the nature of Grade 7 science learners' untutored ability in argumentation?

Sub-questions:

1. What is the nature of arguments constructed by learners?
2. What is the level of argumentation?
3. What evidence do learners use to support their arguments?

1.5 SIGNIFICANCE OF THE STUDY

The study is important because it will help us understand how untutored learners can learn science concepts through argumentation. It will make a contribution on knowledge about how primary science learners participate in argumentation.

1.6 ORGANISATION OF THE STUDY

Chapter 1 provides the introduction and contextual background through a discussion of argumentation as the main concept. I also present the aim and rationale of the study.

Chapter 2 reviews relevant literature on tutored and untutored argumentation that has been carried out in primary schools, high schools and tertiary institutions of learning internationally and in South Africa. Literature pertinent to the research questions was reviewed. The chapter also includes a theoretical framework which was used as an anchor to the study. My study is based on a Vygoskian (1978) socio-cultural theory of learning which views knowledge as collectively constructed between teachers and learners. Argumentation presents learners an opportunity to make meaning of concepts when they actively engage with their peers in an exchange of ideas through verbalization.

Chapter 3 presents an overview of the research methods used in the current study. This is followed by research methods that guide this research. Steps that were followed in the development and validation of the research procedure are discussed.

Chapter 4 provides analysis and discussion of the main findings of this research. Different visual representations such as tables and graphs have been used to discuss factors that may influence nature of argumentation and patterns in argumentation.

Finally chapter 5 presents the conclusions and recommendations.

CHAPTER 2

LITERATURE REVIEW & THEORETICAL FRAMEWORK

2.1 INTRODUCTION

The literature review seeks to explore related research that has been conducted by different researchers on argumentation, tutored teachers and tutored learners, tutored teachers and untutored learners, small group interactions and language issues in argumentation. Before I engage with these issues, I will start by discussing a theoretical framework on which this research is based.

2.2 THEORETICAL FRAMEWORK

This study is located within the Vygotskian (1978) socio-cultural theory of learning which views learning as an activity that takes place in social situations. The theory of learning entails active construction of meaning by the learner through communication, rather than as something that is imparted by the teacher. Although this is the case, there should be teacher-learner interactions which will result in the construction and understanding of scientific concepts. This is consistent with the socio-constructivist conception of learning that says knowledge is constructed collectively through interaction between teachers and learners. Learning takes place through social interaction.

According to Vygotsky (1978) human knowledge is socio-culturally constructed. In other words human knowledge is shaped and transformed by the social and cultural activities in which individuals are involved in their context. Learners acquire knowledge through joint social activities in which they are involved. Vygotsky also maintains that there is transformation of social activities and processes that take place through the process of internalization. For him internalization occurs when an external social activity is reconstructed to occur internally. Internalization helps an individual to understand viewpoints of the others and to use this knowledge to regulate one's thinking. Internalization occurs when understands the perspective of the capable others through the process of mediation. Argumentation involves collaborative effort in synthesizing ideas and making sense of concepts. Vygotsky considers important the process of mediation which is facilitated by the more knowledgeable peers. This process helps the learner to achieve the level of potential development which Vygotsky defines as the Zone of Proximal Development (ZPD).

Vygotsky (1978) defines the Zone of Proximal Development (ZPD) as the difference between the individual's actual level of performance and the level of potential development determined through collaboration with more knowledgeable peers. The ZPD makes teachers aware of the actual level of independent functioning which will provide them the basis from where teaching can begin. The potential level is important since it identifies the gaps in knowledge that need to be developed to the next level. Teaching will be planned from what learners need to know. The ZPD is critical in that it helps to develop

"Those functions that have not yet matured but are in the process of maturation" (Vygotsky, 1978:163).

The ZPD facilitates the development higher mental functions. Vygotsky views pedagogic relations as important in facilitating the basis from communication learning activities could begin through interaction. Vygotsky places emphasis on social relations which suggest collaborative action between the knowledgeable others and the learner. The more knowledgeable others alternatively referred to as "social mediators" are viewed as important agents in facilitating cognitive development. During the process of argumentation, the more knowledgeable will help other learners in learning science. Social interaction is critical in science learning.

Morge (2005) asserts that, social interaction is a process that facilitates learners' individual construction of meaning. Knowledge construction is a social process. Learners have to be engaged in activities that allow them to work together, share and interrogate ideas so as to make meaning of the concepts. Likewise, argumentation involves social interaction leading to a process of sense making. Learners in their groups discuss claims and provide evidence to refute or support these claims and in the process make meaning of concepts. In terms of Vygotskian socio-constructivist theory, the role of the teacher is to mediate learning by guiding meaning making interactions on the social plane of the science classroom so as to assist learners internalize the view of school science.

Mercer (1995), states that knowledge construction must include verbalization in order for it to be shared, and verbalization means to externalize thoughts through talk. For this study it is important that learners construct science knowledge and negotiate meanings through verbalization to enhance the understanding of science concepts. When learners talk, they express themselves through language. Given this, the role that language plays in expressing thinking, understanding and modification, cannot be taken for granted. In this study language

also plays a vital role in enabling argumentation resulting to an understanding of the manner that learners use language to argue and make meaning of science concepts within social interactions.

2.3 ARGUMENTATION

Argumentation is viewed as the ability to establish or validate a claim on the basis of evidence (Norris, Philips & Osborne, 2007). An argument structure can be determined by using a tool commonly referred to as Toulmin's Argument Pattern (TAP). The TAP has different components that are used to determine the structure and presence of an argument. According to Toulmin (1958), the TAP consists of six categories which are *claims*: assertions put forward publicly for general acceptance, *data*: statements used as evidence to support claims, *warrants*: statements used to support data and claims, *qualifiers*: special conditions under which the claim holds true, *backings*: underlying assumptions that are often not made explicit and *rebuttals*: statements that contradict either, data, warrant, backing or qualifier of an argument. The TAP was first adapted for measuring the quality of arguments in science classrooms by Erduran et al (2004) in England. The TAP has been used as a tool in science classrooms worldwide to determine argument structure (Erduran, et al., 2004; Jimenez-Aleixandre, et al., 2000; Braund et al., 2007; Zohar & Nemet, 2002). My study seeks to show the importance of active engagement of learners in the learning process using argumentation.

In the next section, I review literature that reports research on the use of argumentation as a pedagogical tool and as a learning tool. Look at these international studies on argumentation, a lot of it has been done in high school and there has been a little in tertiary not much in primary. I didn't find anything on primary science argumentation in South Africa, so my research is filling this gap.

2.4 LITERATURE REVIEW

In this chapter, I review the literature on the following groups' ability to engage in argumentation during the teaching and learning of science: tutored teachers and tutored learners, untutored learners and tutored teachers. By tutored I mean learners who have been taught how to use argumentation and untutored is used to refer to learners who have not been taught how to use argumentation during teaching and learning of science. I will examine studies that have been carried out locally and internationally on tutored and untutored learners' ability to argue in science. In addition I will also look at other factors that impact on argumentation such as small group interactions and knowledge on domain specific content.

2.4.1 TUTORED TEACHERS AND TUTORED LEARNERS

Literature has shown that tutored learners can argue at high levels and tutored teachers help these learners to argue. Tutored learners are learners who have been taught how to use argumentation in when learning science. Tutored teachers do help learners engage in argumentation by selecting activities that require learners to actively participate in discussions. Teachers may also give learners different knowledge claims to work with as evidence to support or disqualify claims. Such tasks give learners opportunities to participate in learning by making known their views through discussions. A study by (Naylor, Keogh and Downing 2006) has shown high levels in argumentation which involved tutored teachers and learners who were untutored in argumentation. In their study they used the concept of argumentation to analyse the extent to which learners at primary school engage in argumentation in the United Kingdom.

Concept cartoons, is a concept that is used to get learners involved in discussions during science lessons. Pupils in groups are presented with cartoons relevant to the concept taught in science. A study by Naylor, Keogh and Downing (2006), shows that pupils had learnt about gravity and force. They were then presented with the concept cartoons to show what forces will be acting on a person moving on a skateboard. Pupils discussed why the person using a skateboard eventually stops at some point. Learners explored all the possibilities and eventually agreed on possible reasons. The concept cartoons, stimulates learners to engage in conversations since they present what learners are familiar with in their everyday lives. In exploring solutions, learners support their views by linking these views with science evidence.

Naylor and colleagues studied two primary schools and used observations to investigate the nature and quality of argumentation. Pupils were observed in science lessons and afterwards the lessons were discussed with small groups of pupils and with teachers. The analysis of the lesson was carried out using the Downing model framework by Mercer et al (1999), which focuses on the nature of interaction between individuals. We don't have many of these kinds of studies in South Africa. In their study (Naylor, Keogh and Downing 2006), pupils worked in small groups and participated during whole class discussion. Some groups were able to sustain arguments. They were able to give views and probe each other's views. The results suggest that learners are able to argue if presented with concept cartoons. The concept cartoons provides' a stimulus for learners to engage in discussions. In all lessons, pupils explored different view-points built on each other's contribution and agreed on solutions. Pupils in the study had different backgrounds in terms of race and language but they were able to engage in argumentation successfully. The findings also suggest that language does not completely deter pupils' ability in argumentation.

The results also suggest that if all pupils are to scaffold each other's learning, the group must be large enough to enable this to happen. Interestingly a study by Maloney and Simon (2006), confirms that there are some children who can drive the process of scaffolding small group discussions Children who have a higher level of ability in terms of performance and have been taught how to argue, are able to scaffold group discussions. Such children do engage critically and constructively in discussions. They challenge evidence given by others and discuss alternatives. The group will then adopt a common standpoint having explored all alternatives. This is important to my study because I was working with children who show adequate performance in science although they are untutored in argumentation. I wanted to find out if they were able to argue, how they argued and sustained their arguments.

Apart from learner ability the size of the group is equally important. If all group members are to have the opportunity to engage in worthwhile argumentation the groups must be small enough to provide suitable opportunities for all to contribute to the discussions. In my study learners were placed in small groups of four to ensure that every learner had the chance to participate. Since learner activities were designed and monitored by the teacher who was tutored in argumentation, it is important then to discuss whether there was influence in learner performance in argumentation. The study by Naylor, Keogh and Downing (2006), argumentation appeared to be more productive in the absence of the teacher. The presence of the teacher seemed to affect learner argumentation. Some learners would shy away from

participation during the presence of the teacher and only get involved when they work alone with their peers. Learners don't just talk when the teacher is there. However this appears to be inconsistent with D. Kuhn et al.'s (1997) findings that any carefully planned activities help learners develop skills of argumentation without the teacher helping them.

In a similar study, Maloney and Simon (2006) conducted research in London with untutored students to examine whether 10-11year old children could engage in argumentation in small groups using evidence to support their decision in science. This is an important study for me because it is related to my study in which I worked with learners who are untutored in argumentation.

The findings from Maloney and Simon (2006) study, also suggest that although some groups worked cooperatively, they did not work collaboratively. Working cooperatively is when pupils are part of the group but may not be active participants and will simply agree with the leader. In a collaborative group there is active engagement of everyone, where everyone is involved in exploring ideas, building on each other's ideas and coming up with a shared meaning. In Maloney and Simon's study (2006) there was no negotiation to reach a consensus, some children made decisions without consulting group members. In such groups low level of argumentation has been reported. This means that, the ability to review views and reaching a consensus is a pre-determinant of high level argumentation.

Maloney and Simon (2006), argue that quantity of claims supported by evidence does not necessarily indicate the quality of argumentation. It is rather the process of exploring different types of evidence that is characteristic of a good argument. Narrowing the discussion, results in good argumentation. In a way it is during discussions whereby children bring about many different views which they explore and review. Only a few of the views are considered which get to be reviewed until they come reach a consensus view based on evidence. It is the quality of evidence that result in good argumentation. Familiar topics aligned to everyday events have an effect on quality of argumentation.

In a South African study, Braund, Lubben, Scholtz, Sadeck and Hodges (2008), studied socio-scientific topics and pure scientific topics to find out the nature of student interactions in argumentation. The study was done with high school learners who were tutored in argumentation. One group was asked to discuss whether the Euglena is a plant or an animal and the second group argued in support or against trafficking of organs.

High levels of argumentation were reported in both lessons in some episodes. Learners had been taught argumentation and were aware of what constitutes a good argument. The nature of activities allowed learners to create claims, explore their responses through group and class discussions. Teachers also helped improve argumentation by probing learners' responses to elicit rebuttals. A study by Naylor, Keogh and Downing (2006), revealed that learners do not talk when the teacher is present. Argumentation would occur only during the absence of the teacher. In their study Kuhn et al. (1997) findings did show that it is the carefully planned activities that helped learners to engage in argumentation without the teacher's interference. Therefore learners do argue when the activities are suitably designed to promote argumentation. The teacher will help promote argumentation through probing and guiding learners.

The aforementioned factors in the study by Braund, et al (2008), contributed to the quality of argumentation achieved in the study. The findings further revealed that there were many high quality arguments about the euglena comparably to the concept about organ trafficking. The socio-scientific about organ trafficking had a few rebuttals. The differences on quality of argumentation in the two lessons may be attributed to several factors. The concept of organ trafficking is a familiar socio scientific topic. The euglena concept is a scientific concept that requires content knowledge on the subject matter. Argumentation in scientific concepts, are highly informed by factual subject knowledge. Learners engage much easily with familiar topics.

Presentation strategies impact on argumentation process. In the lesson about organ trafficking learners were presented with the opportunity to engage in different activities such as reading, role play and debate. The different activities help to get more learners involved in discussions and sharing and critiquing opinions resulting in shared meanings. However in learning about the euglena organism, learners got evidence cards which they had to put in correct category and justify choice. There were limited activities which was not enough to get all learners to explore and express their opinions. Results in the study show that when teachers and learners are tutored you get high level of argumentation. These findings are relevant to my study because I wanted to examine how learners engage in argumentation in my classroom context with a tutored teacher in argumentation.

The study by Braund, Lubben, Scholtz, Sadeck and Hodges (2008), shows that when learners are tutored in argumentation they produce better quality of argumentation if they are familiar

with the content. The study also indicates that lesson presentation and type of questions affects the outcome in terms of argumentation. During the lesson about Organ trafficking, closed questions were asked which did not promote discussions. Learners were asked to list claims for and against the concept of Organ trafficking hence restricting learners to provide evidence to defend their claims. Learners were asked closed questions which then blocked opportunities for learners to provide reasoned arguments. There is need for open questions which will invite discussions, explore different views and closed questions which will help learners to justify their decisions. These findings further reveal that when both teachers and learners are tutored there is a high level of argumentation. However, it has also been seen that argumentation can happen with untutored learners as was the case with the Lubben, Sadeck, Scholtz and Braund (2009) study discussed in the next section.

2.4.2 STUDENTS' UNTUTORED ABILITY IN ARGUMENTATION

Argumentation research has been conducted with untutored high school learners in South Africa. This study is important because it shows what happens at high school where learners' are untutored and the teacher is tutored in argumentation. My study wanted to find out what happens if a similar study is carried out at primary school. Lubben, Sadeck, Scholtz and Braund (2009) conducted a study into the untutored ability of Grade 10 students to engage in argumentation about the interpretation of experimental data, and the effect of unsupported small group discussions on this ability. The sample of 70 friendship groups of four was drawn from eight classes in five schools in Cape Town. The schools were resourced differently with three of the five schools having better resources and qualified teachers.

Results indicated that before the group discussion most Grade 10 learners' argumentation is at Level 1 or 2. There was a slight improvement after small group discussions. This is an indication that something happens during group discussions. Students do discuss and explore alternative claims and in the process scaffold learning whether they are tutored or untutored in argumentation. In the Lubben et al (2009) study, most of the groups did argue to reach a concensus, views that were different were not considered. If learners are untutored in argumentation, discussions are only meant to reach a consensus rather than meaning making. Views that are different are not entertained. This results in low argumentation. These findings show that when teachers are tutored and learners are untutored the level of argumentation is low.

In my case, I am a tutored teacher with untutored learners so I wanted to see how untutored learners engaged in argumentation. I am not focusing on myself; I am focusing on my learners because I am saying something must have passed on from me to my learners, If it hasn't then I need to know so that I can start structuring my teaching like a tutored teacher teaching untutored learners.

In a related South African study by Msimanga and Lelliot (2012), there were contrasting findings. The study looked at whole class discussion at high school by a tutored teacher and untutored learners in argumentation. The study showed that argument construction in whole class discussions could be used as a tool for joint meaning making. Msimanga and Lelliot (2012) noted that although learners were untutored in argumentation, they were able to provide rebuttals. This is contrary to the findings by Lubben et al (2009) who reported low levels of argumentation despite the fact that both studies dealt with pure science concepts. According to Msimanga and Lelliot (2012), the teacher scaffolded learning by guiding and supporting learners through probing. Learners were also familiar with concept being taught in chemistry. Argumentation was successfully used as a tool for shared meaning- making through questioning and evaluating arguments. In the Lubben papper, the concept on measurement seemed unfamiliar to learners from under-resourced schools. Closed types of questions were asked with no guidance and support. Apparently, there is need for guidance and support to help learners who are untutored in argumentation, if argumentation is to be used as a tool for meaning- making.

The Braund, Lubben, Scholtz, Sadeck and Hodges (2008) study reported low level argumentation in a pure science concept yet Msimanga and Lelliot (2012), found high level quality argumentation. Seemingly, the ability to scaffold interaction with 'thinking questions' probing results in learners making meaning of science concepts during argumentation. The generation of higher order questions by the teacher and probing led to high level quality argumentation. In addition it can be argued that learners do engage in high level argumentation if they have grounded content knowledge or prior knowledge about of a specific concept. However, failure to engage in argumentation on pure science concepts could be a symptom of lack of base knowledge on the key concept and the nature of questions asked. If closed questions are asked first, they will not encourage learners to engage in discussions as opposed to open- ended questions (Lubben et al, 2009). Open- ended questions will encourage learners to explore other ideas and review them.

Jimenez-Aleixandre, Rodriguez and Duschl (2000) also recorded the effect of open ended questions on untutored high school students' argumentation. They observed high level ability to develop and assess arguments in genetics and attributed this success to the structuring of the lesson. Open ended questions were used to get students to discuss colour differences in the feathers of farmed and wild chickens. Then the students were given different claims and were to discuss merits and demerits of each claim in order to decide on the possible causes of the differences.

The results were classified in two categories: "Doing the lesson" and "Doing Science" where the former involves students engaging in science lesson routines such as taking notes, completing lab activities, rules for the task, incidental talk and the latter was about talking science, engaging in a scientific dialogue or argumentation and evaluation of knowledge claims (Jimenez-Aleixandre, Rodriguez and Duschl, 2000).

In Jimenez paper, learners were untutored but the teacher was tutored. The study also confirms that untutored learners do argue and sometimes do present high level argumentation by using correct science evidence. However their ability and quality of argumentation is also influenced by what the tutored teacher is doing during the lesson. This was another study that was done high school. I wanted to see what happens in primary science lessons with untutored learners taught by a tutored teacher.

In their study Lubben, Sadeck, Scholtz and Braund (2009) noted that some group factors affected argumentation. Group dynamics may hinder or promote argumentation. These include purpose of group discussion, nature of group approach to discussions, whether authoritative or democratic. Their findings showed that most of the groups thought that discussions must always lead to a commonly agreed argument. In groups that used the democratic approach only the majority views were important. In some groups only the views of an authoritative member were considered. The following section reflects more on group dynamics during small group and whole class discussions.

2.4.3 SMALL GROUP INTERACTIONS

Argumentation is dependent or is influenced by group size. Since small groups are known to favour interaction anywhere they are likely to favour argumentation. I will show how various studies enhanced argumentation. I will also show how argumentation was affected during small group discussions and say what I will do in order to mitigate this in my study.

Some researchers have carried out studies on use of argumentation using small groups and whole class method to teach science concepts. Yackel, Cobb and Wood (2001), carried out a study about the use of small groups and whole class problem solving as an instructional strategy in mathematics. The purpose of their study was to investigate how small group interactions create learning opportunities when used in the teaching and learning of mathematics to second grade learners. The study involved a tutored teacher and untutored learners in argumentation. A Vygotskian approach of social interaction was used to facilitate the learning of mathematics.

A regular teacher taught the second grade learners mathematics using co-operative learning strategy throughout the year on different topics. Instructional activities were designed to give rise to problematic situations for the children. The children were put into both homogenous and heterogeneous (boy and girl) pairs. The children were also paired according to their social interactions and their mathematical development. Learners, known to be friends with similar mathematical ability, were paired together. It was found that pairing children who differ widely in mathematical development was less productive than pairing of children who are more homogenous in this respect. Groups consisting of members, where one learner shows excellent performance in mathematics and a learner who has difficulties in mathematics, proved ineffective than in groups where learners had similar performance ability. No argumentation would take place in such a group. The weaker learner would simply adopt all answers given by the intelligent learner.

The teacher observed children and guided their talk. This helped teachers ensure that the more brilliant children did not just write without discussing with their counterparts. If children are not engaging with each other it would disadvantage those children who have a different opinion since they would not know why a given answer is said to be correct, which could be different from theirs. They will be denied the opportunity to learn. Sometimes children would spend most of the time on one problem instead of moving on. This may possibly be a result of a child or some children not having grasped the concept and persist in getting an explanation. The teacher's movement to different groups to observe and listen to children's discussions was important. It helped children to discuss and learn to insist if they do not understand the concept. It also helped the teacher to later use her/his observations during feedback session.

According to Yackel et al (2001), use of small groups is a strategy that encourages collaborative dialogue which results in resolution of conflicting points of view. A dialogue is central in the learning process because when children talk to each other, they make known their views and deliberate on each other's perspective and in the process making meaning of the concept. In this way children are able to use each other as resources in the construction of knowledge. Learners were able to argue and learn because the teacher would ask questions and guide the learners. Pair work helped to develop in learners skills of learning to work together in order to solve mathematical problems. The study shows that small groups will favor argumentation.

Learning opportunities are only created if the children work together productively and attempt to solve mathematical problems. A study by Richmond and Striley (1996) examining student talk in working groups revealed that students become much better at using the scientific method to construct convincing evidence. Learners moved from generalizing to asking specific science related questions which raised learners' ability to formulate arguments. The teachers also helped learners to initiate discussions. Their findings showed that engagement was low in the group led by an alienating student. Much of the time was spent off the task. The quality of student's arguments was high in both inclusive and persuasive groups. In inclusive groups, arguments were co-constructed by all group members unlike in persuasive groups where the leader was responsible for constructing the argument. Richmond and Striley concluded that, argumentation revolves around inclusivity where meaning is constructed collaboratively,

"Our goal as science educators is to provide an environment in which knowledge construction is like that of scientific communities, but with participation of all members." (Richmond and Striley, 1996:856).

This means that the goal should be for all students to participate in the generation of knowledge and this can happen through argumentation. Yackel et al, (2001) maintain that, when children work together and strive to communicate, opportunities arise for them to verbalize their thinking, explain or justify their solutions. Levina, (as cited in Yackel et al 2001) maintains that language can help children clarify their own understanding by talking and reconceptualising their own cognitive constructions as they attempt to make sense of their partner's explanations. In support of the language effect in argumentation, Means and Voss (1996) found out that knowledge is related to some other aspects of argumentative thinking, such as generating more reasons or stating more qualifiers, but not to other aspects.

Learners use language to communicate and publicise their views. Language may affect the quality of arguments generated during discussions. Learners therefore need to be afforded the chance to engage in discussions so that they can exchange views and support their claims through talk. When learners externalize their thoughts through discussions, they use language. Language plays an important role in the development of mathematical concepts. Learning opportunities also arise as children work together and use language to share their thoughts. When one child makes an error and the other child attempts to assist the first child in clarifying his or her thinking, it will help the child who has made the error to have a better understanding of the concept.

In a study of high school students in Greece, Alexopoulou and Driver (1996) also showed the importance of group work in allowing students to help each other to understand concepts. Alexopoulou and Driver (1996) also conducted research on small group discussion. The students who participated were aged 14 to 15 and were of mixed ability. Children were grouped in pairs and in fours and these were homogeneous groups.

The results showed that children who were grouped in fours progressed slightly more than those in pairs in all four classes. This suggests that group discussion in fours helped children to progress in their physics reasoning more than group discussion in pairs. In pairs learners found it difficult to negotiate their conflicting views whereas in fours learners were able to generate more views to explore and negotiated meanings. These findings suggest that the size of the group matters for effective discussion. Therefore, in my study it was important to put learners in groups bigger that just two. This study differs in purpose from the Yackel study which used pairs of friends to get learners to learn to work collaboratively and talk to each other. In the Alexopoulou and Driver paper, what was critical was the ability of learners to generate alternative views to explore and negotiate meanings in order to arrive at the correct scientific response.

Alexopoulou and Driver (1996) share the same view with Yackel et al (2001) that, talk with both peers and teachers is at the centre of children's conceptual understanding. The role of discussion in learning is interpreted within a number of theoretical perspectives such as the Piagetian and Vygotskian perspectives. The Piagetian perspective emphasizes on the personal construction of knowledge through the interaction between the individual's knowledge schemes and his or her own experiences of the environment. Focus is on the psychological process of equilibration. From this perspective, talk with other people is seen as a process

that creates cognitive dissonance. The Vygotskian perspective views the construction of knowledge as a social process. Since children's meanings are socially derived, talk with adults or more capable peers is considered to be the best for any subsequent learning. Talk is therefore central in the science learning process.

In order to learn science, children must have a language to use including the scientific terms which are the tools of the science discipline. Learning takes place when talk and debate about concepts happens using the scientific terms. Peer talk has been seen to offer children the opportunity to construct new ways of understanding through a collaborative negotiation of their meanings. When learners work in groups to discuss concepts they engage each other's views, negotiate and use evidence to justify view points, they make meaning of concepts. Studies by Brook and Driver (as cited in Alexopoulou and Driver 1996) , which focus on the social processes of knowledge construction in groups show that peers' negotiation of meaning about the subject matter is linked to the negotiation of their social interaction on the social plane. In a way there are a variety of other factors such as children's attitudes and behaviors that influence the way they negotiate. Seemingly, during negotiation confrontation cannot be ruled out in a learning situation and this requires skilful resolution.

Children need to be taught how to negotiate when presenting their arguments in order to allow the process of learning to take place. If learners are not able to negotiate and work together as a group, learning may not happen. The nature of the evidence given by learners also affects the quality of argumentation. I selected groups following the chronological order in class register. For my study, putting learners with different performance ability did not matter.

2.4.3 ARGUMENTATION SKILLS

Zohar and Nemet (2002) carried out a research on fostering knowledge and argumentation skills in the context of dilemmas in human genetics. The aim of their research was to analyse the learning that takes place when explicit teaching of reasoning patterns is integrated into teaching of scientific content. This research was conducted in a regular junior high school (Grades 7-9) and a heterogeneous school, with students of mixed abilities. This study involved a tutored teacher with untutored learners in argumentation. This study is relevant to my study because I wanted to find out whether learners who are not tutored in argumentation but taught by a teacher who is tutored in argumentation can argue.

Learners discussed questions from excepts about the Huntington's disease dilemma. The learners were successful in formulating simple arguments. These findings suggest that even before instruction most learners could formulate arguments, and rebuttals but these arguments tended to be simple, consisting of only one justification and having a simple structure.

However an increase was found in the frequency of students who referred to correct, specific biological knowledge in constructing arguments after explicit teaching of argumentation into the teaching of dilemmas in human genetics. It was concluded that the teaching of argumentation skills enhances performance in both biological knowledge and argumentation. The study shows that tutored learners argue at higher levels. Seemingly argumentation needs to be taught if learners are to acquire science knowledge. Zohar and Nemet (2002) argue that learners need to be taught reasoning patterns with specific science content. Scientific arguments follow a certain structure which determines simple and complex arguments. They further argue that thinking patterns are content dependent, which means if learners have sound content knowledge on the subject matter, they are likely to generate quality arguments. Aufschaiter, Erduran, Osborne and Simon (2008) also support the view that effective argumentation occurs when students are familiar with concepts.

In their study of junior high school and university students' processes of argumentation and cognitive development in science and socio-scientific lessons, Aufschaiter et al (2008) found that students could achieve a higher quality of argumentation that consists of well grounded knowledge with a relatively low level of abstraction. Findings suggest that familiarity with the content enabled the students to think about it at a relatively high level.

Average and lower ability students are likely to present low level arguments while gifted students will exhibit high level arguments.

2.4.5 CONCLUSION

In this chapter I presented the theoretical background to the study and reviewed literature on argumentation and group work. On the basis of reviewed literature it can be deduced that argumentation happens in science lessons whether learners are tutored or untutored in argumentation. However, untutored learners tend to make low level arguments. There were also reflections on factors that seem to influence the argument patterns and the nature of evidence used to support arguments presented by learners which included group dynamics and learner performance and achievement. Most of the literature showed how tutored

teachers and tutored learners do as well as how tutored teachers and untutored learners engage in argumentation at high school and at university. There is very little literature on argumentation in primary schools. My study aims to address this gap in knowledge of argumentation in primary science.

In the next chapter, I will discuss my research design and methods that I used in the study.

CHAPTER 3
RESEARCH DESIGN

3.1 INTRODUCTION

This section begins with a presentation of the aim of this research followed by a discussion of the research procedures followed in answering research questions. I conducted a case study of a primary school among Grade 7 learners. The purpose of the investigation was to determine whether and how South African learners who are untutored in argumentation construct arguments. The study was guided by the following research questions:

1. What is the nature of arguments constructed by learners?
2. What is the level of argumentation in a Grade 7 science classroom?
3. What evidence do learners use to support their arguments?

I will now describe the research design which guided me infer and interpret information gathered in order to address afore mentioned research questions. The research design is important because it outlines the ways for carrying out research. According to McMillan and Schumacher (2001), research design ‘’specifies a plan for generating the evidence that will be used to answer research questions’’ (p.20). It also maps out the entire study in line with the purpose as well as the type of research to be undertaken. I am taking a socio-cultural perspective of learning and within it talking, discussion or engaging with each other is important. I looked at all forms of talk that took place in the classroom to determine whether and how argumentation was used. Thus a qualitative case study was chosen as a design for this study.

3.2 QUALITATIVE RESEARCH

Since the research questions were essentially exploratory in nature, they could be more effectively addressed through a qualitative methodological approach. Macmillan and Schumacher (2006) define qualitative research design as a research method used in describing and analysing people’s individual and collective actions, beliefs, thoughts and predictions. According to these authors, the researcher using this design interprets phenomena in terms of people’s meanings. My study seeks to establish learners’ ability in argumentation which can be determined by analysing individual talk and collective effort. They also describe it as: “interactive, face to face research, which requires relatively extensive amount of time to systematically observe, interview, and record processes as they occur naturally” (Macmillan and Schumacher, 2006:340). Similarly, Mwiria and Wamahiu

(1995) indicate that the use of this method is important as it studies humans who unlike animals, posses consciousness which for them is a unique concept.

Strauss and Corbin (1990:17) define qualitative research as: "Any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification." This shows that this method does not use statistical information like quantitative method does. It is rather interested in how people make sense of their lives, experience and their structure of the world. It therefore provides information about the human side of such issues as behaviours, beliefs, emotions and their relationships as individuals. During the argumentation process, learners gave contrasting perceptions about concepts and supporting views. It was therefore important for me to observe certain behaviour shown by learners during discussions to understand how they made sense of concepts.

Qualitative research method also help people to understand any phenomenon about which little is already known or gain more in-depth information that may be difficult to convey quantitatively (Strauss and Corbin 1990). Qualitative data collection methods include observations and group discussions. The results from qualitative studies often cannot be generalised but are context dependent. My study is a qualitative research and it means that the results from this study are also context dependent. This is important to this study because the research covered only a small sample, a primary school in Gauteng. The study may only yield same results if carried out in a similar context.

The advantage of using this method is its ability to provide more information, which has influenced me to use it. This benefit is also mentioned by Wienriech (2006) who points out that the use of this method helps to produce rich, detailed information that leaves participants perceptions intact and presents a context for healthy behaviour. This indicates that people's views are respected and regarded as important when this method is used. However, qualitative research method may also have some disadvantages as pointed out by Smith (2008) who states that subjectivity in this research design leads to problems of reliability and validity of information gathered. In an attempt to address this problem, lesson recordings were transcribed verbatim and the supervisor also cross-checked the information. I used this approach because it allowed me to gather a lot of information which I then analysed in order to understand how argumentation helped learners to learn.

3.3 CASE STUDY METHODOLOGY

Opie (2004) defines a case study as an in-depth investigation into a single instance in a bounded system. A school can be regarded as a single case amongst other institutions. According to Flyvbjerg (2007) a case study is well suited to produce, concrete, context-dependent knowledge, and my study will produce such knowledge in terms of the context which is a primary school setting in South Africa. Case-study investigations like all other models of research have their own short-comings. Delamont (1992) criticizes case studies for the difficulties they pose in generalizing the research findings. However Patton (1990) argues that case-studies are not about generalizations. Instead they seek to describe research settings, situations and experiences from which others can draw to understand own or similar social phenomena. I agree with Patton's (1990) argument that for a case study relatability rather than generalization is important. In the case of my research I may not be able to generalize the findings to all South African science classrooms in primary schools, but my study can inform other similar teaching contexts in South Africa.

3.4 SAMPLING AND THE SAMPLE

There are different sampling methods that a researcher can use to collect data such as purposive and convenience sampling. Patton (1990) identifies a convenience sampling strategy whereby participants are selected in terms of accessibility, time and financial considerations. Purposive sampling relates to what the selected group of learners will bring to the study, with the assumption that they have knowledge about the topic or will be able to engage with the activities as required. In this study I used both convenience sampling and purposive sampling. This study was conducted at a primary school in Johannesburg in the Gauteng district. The school has been selected because of its convenience in terms of accessibility and time. Purposive sampling has been used for the study because I was dealing with the subjects who were untutored in argumentation. Such subjects would provide the best information to address the purpose of the research. I chose a Grade 7 class because I teach the class and I am a tutored teacher in argumentation. The class was chosen for convenience and I also wanted to know about learners' engagement in argumentation in the primary school.

The sample of this study consisted of 75 learners from two Grade 7 classes. I was the researcher and I taught the two Grade 7 science classes. The school where the research was carried out is a multilingual school but the language of teaching and learning is English. For all participants, English was their second language. I taught them the topic insulation and

energy saving. The topic was selected because it was amenable to argumentation. I designed worksheets with questions from the topic. The questions were carefully structured in such a way that of the six questions on a worksheet, only two were targeted for discussion. The two questions were thought- provoking and were deliberately included so that they would promote learner engagement. I also listened to learners discussing during the lessons so as to understand how they engaged during argumentation process.

3.5 CLASSROOM OBSERVATION

Montgomery and Hadfield (1989) noted the importance of observation in understanding teaching and learning. It provides the researcher with information about the participants within a short space of time. The audio-recorder helped me to capture learner talk verbatim during transcription of the description.

I recorded all groups per lesson in each class. Each of the ten groups had an audio recorder. For whole class discussions, I was relying on the teacher's audio recorder which was placed on the teacher's desk in front of the class.

I followed discussions of four groups, two groups from each grade 7 class. Each group had four learners. For an in depth study, the four groups would be manageable to follow and tease out fine details in data analysis. The groups were made of the average, below average and above average learners. Average learners are learners whose performance in science is at 50%. Learners below average perform below 50% and above average learners perform above 50%; the groups were also heterogeneous and homogeneous. The table below describes the participants:

Table 3.1: A description of groups

CLASS	GROUP	BOYS	GIRLS	BELOW AVERAGE	ABOVE AVERAGE	LEARNERS PER GROUP
7-1	1	1	3	-	3	4
	2	2	2	3	1	4
7-2	3	4	-	-	4	4
	4	2	2	3	1	4

The table above shows a description of participants in each group according to gender and academic performance.

3.6 SUMMARY OF THE LESSONS

I recorded four lessons in each class (see appendix 1a-2f). Lesson 1 was on Insulation and energy saving. In this lesson, learners had to investigate a material that retains heat. The whole class conducted the experiment. In small groups, learners discussed questions and gave feedback. Lesson 2 was about conservation of heat in homes and buildings. In their groups learners read information from a resource sheet responded to questions in their groups and gave feedback which was followed by a whole class discussion. Lesson 4 was on energy efficiency in power stations. Learners interpreted information from a cartoon strip on wasted energy, discussed sources of electricity, how electricity is generated, useful and wasted energy. They discussed in small groups and gave feedback which resulted in whole class discussions.

3.7 DATA COLLECTION METHODS

All lessons on selected topics were audio-recorded, transcribed and analysed in-order to understand the nature of talk in the classroom, learners' alternative conceptions of science concepts and the nature of argumentation. I used the different teaching methods such as the whole class discussions, small group discussions and cartoon strips. I showed learners a cartoon strip about energy transfer. Learners responded to questions based on the cartoon. I listened to each lesson and this informed how I was going to present the following lesson.

3.8 DATA ANALYSIS

According to McMillan and Schumacher (2010), data analysis may be iterative during the collection phase. In line with this view, I collected data and started to analyse it at the same time. Data gathered from small groups, whole class discussions and individual written work was transcribed, coded and analysed. Analysed data would provide an insight on how the teacher facilitates argumentation. I used Toulmin's Argumentation Pattern (1958) discussed in the literature review to determine if learners constructed any arguments. I counted the number of claims, data, warrants and rebuttals. In order to determine whether there was low or high level of argumentation, I used the framework of analysing argumentation designed by Erduran, Simon and 0sborne (2004). I categorised the arguments according to the following categories in Erduran's framework for argumentation.

Claims only: *claims and data*: *claims, data and warrants*: *claims, data, warrants and qualifiers: claims, data, warrants and rebuttals.* Low quality argumentation is determined by the presence of claims only. Use of warrants, qualifiers and rebuttals indicate presence of high quality of argumentation.

3.9 VALIDITY AND RELIABILITY

In order to check that research findings are not biased and are reliable, the validity and reliability of the research instruments need to be checked (Sanders & Mokuku, 1994). ‘’Validity’’ refers to the extent that scientific explanations of the research phenomena match the realities of the world or its population. ‘’Reliability’’, in contrast refers to the consistency of the test instrument and its use (Cohen & Manion, 1994). Reliability addresses the extent to which independent researchers could discover the same results using the same instruments under the same conditions whereas validity involves checking whether the content items measure the concept that they assume to measure.

Validity in qualitative research reflects the extent to which given explanations in the study agree with the reality on the ground (McMillan & Schumacher, 2001). In this study analysis of the transcripts, data from the audio recording and classroom observation will enhance validity. The data captured in transcripts and audio recordings can be cross-checked to ensure validity. Yin (2003) maintains that to prevent possible sloppiness in a case study, all efforts must be made to thoroughly go through all data. This means that the captured data must be checked so that it is reliable. This study takes Yin caution seriously and I used interator reliability to ensure validity. Besides me looking at the analysis, my supervisor also looked at the analysis so that there is inter reliability. The supervisor read the transcripts, coded the data and looked at the episodes. The coded data by the supervisor and my results of coded data were analysed and validated.

Henning (2004) posits that data itself is not valid or invalid, but it is the reference that is drawn from it that determines its validity. I ensured that the research report captured as much details as I could from the participants’ perspectives. I did capture much information from participants’ perspectives through audio recording and transcription of data in verbatim. Continued consultation with my supervisors as well as my peers with regard to emerging findings, as well as clarification of any assumptions with participants assisted me to provide valid data. I also asked another person to use TAP on a small sample of my data to compare results. The results were the same which further enhanced validity.

3.10 ETHICAL CONSIDERATIONS

The purpose of my study was clearly outlined to all participants involved in the study. They were assured that their privacy would be protected (Henning, 2004). Anonymity was guaranteed through the use of codes in place of their names. It was also my responsibility to make it known to my participants that it was their right to decide whether to participate in this research or not. Consent letters were sent to both learners and their parents before I commenced with the study and only started data collection when permission had been granted. They were also informed as to how the research study would benefit them. I obtained an ethics clearance from the University of Witwatersrand. Permission was granted by the Gauteng Department of education to conduct the research at the school.

3.11 CONCLUSION

This chapter discussed details of the research design and methods used for data collection and analysis of the findings for the study. The selection of the qualitative research design, proved to be useful in this study as it allowed detailed data collection methods. The reasons for the choices of the methods to collect data were also clarified. These methods included lesson recordings and lesson observation. Data presentation is provided in the next chapter.

CHAPTER 4
RESEARCH FINDINGS, ANALYSIS AND INTERPRETATION

Introduction

The study reported in this research report aimed to present an analysis of the nature of argumentation presented by untutored learners.

I wanted to determine whether and how Grade 7 science learners who are untutored in argumentation construct arguments and how they support their arguments.

The study addressed the following research questions:

1. What is the nature of arguments constructed by learners?
2. What is the level of argumentation?
3. What evidence do learners use to support their arguments?

This study is informed by Vygotsky's (1978) socio-cultural theory of learning which views learning as an activity that takes place in social situations. The central idea is that human knowledge is shaped and transformed by the social and cultural activities, which individuals are involved with in their context. Thus teaching and learning is a social process which results in knowledge development. Similarly, argumentation involves social interaction during the process of sense making hence its location within the socio-cultural theory. Since argumentation involves social interaction, I used small groups and whole class discussions to address the above research questions.

4.1 DATA ANALYSIS

To analyse data, I drew from an adaptation of Toulmin's Argument Pattern (TAP) by Erduran, Simon and 0sborne (2004). The TAP was used to code data. According to Toulmin (1958) an argument has 6 components which are claims, data, warrants, backings, rebuttals and qualifiers. The claim is any form of conclusion-an assertion, a statement meant to answer a question. Data includes any evidence that supports the claim. Warrants provide the link between the claims and data. Backings are any scientific information, theory or law that explains how the warrant links the data to the claim. Warrants and backings provide justification for how the data supports the claim. Rebuttals are any assertions about situations where a claim is not valid or when it may not hold true. I used the TAP model to describe the argument structure in the lesson and the pattern in different episodes. Episodes are moments

of learner engagement in discussions about a concept. By argument structure I mean how many claims, data, warrants, backings, rebuttals and qualifiers in an episode. Table 4.1 below shows the components of argument used in coding data.

Table 4.1: Components of an argument

C :	Claims	- assertion, conclusion
D :	Data	- observations, evidence
W :	Warrants	- link between claim and data
B :	Backings	- link between warrant claim and data
R :	Rebuttals	- where a claim is not valid
Q :	Qualifiers	- conditions under which the claim holds true

Episodes of the lessons were analyzed using the above analytic framework. The above table which is the TAP was used to identify components of an argument and to address the first research question.

Analytic framework used for assessing the quality of argumentation

Table 4.2: a description of levels in argumentation

Level	Description of levels
1	Argumentation consists of arguments that are simple claim versus a counterclaim or a claim versus a claim.
2	Argumentation has arguments consisting of a claim versus a claim with either data, warrants or backings but do not contain any rebuttals.
3	Argumentation has arguments with a series of claims or Counterclaims with either data, warrants or backings with the occasional weak rebuttal.
4	Level 4 argumentation shows arguments with a claim with a clearly identifiable rebuttal. Such an argument may have several claims and counter- claims.
5	argumentation displays an extended argument with more than one rebuttal.

Adapted from Erduran, Simon and Osborne (2004:928)

The Table 4.2 shows the different categories that can be used to explain the quality of argumentation. Erduran et al (2004) described the simplest arguments as comprising a series of claims or unjustified counterclaim and they termed this level 1 argument. This type of argument indicates that the students' argumentation skills are still basic. Claims only with no evidence do not amount to a valid argument. Arguments in level 2 are simple arguments. Arguments in level 3 and 4 are good quality arguments. The most complex argument comprises of all of Toulmin's components in an extended argument with more than one rebuttal. These are arguments in level 5 and are arguments of very good quality.

The above table was used to analyse each episode in order to determine the quality of the arguments in the small groups and this addressed the second research question. Data from the transcripts was categorized into episodes. Firstly, each episode was analyzed using TAP to identify major components of an argument contributed by the individuals in the group. Secondly, the components were summarised and then analyzed using the Analytic framework to determine the quality of arguments presented.

This is an extract from lesson 1 of group 1 and represent episode 1, which gives an insight on how I used the TAP as an analytic framework to analyze data.

Question: Why should the bottoms of the containers also be covered?

5 ***Senzo****: All the containers must be covered because heat can be lost under the container.* ***Rebuttal***

6 ***Ben:*** *Why is that the bottom has to be covered because the top is not covered?*

Counterclaim

7 ***Senzo****: The top is not covered because we cannot. Where would we put the thermometer?* ***Data***

8 ***Ben:*** *Will that make the investigation correct?*

9 ***Senzo:*** *Yes because the rest of them are not covered* ***Claim***

10 ***Ben****: But if you say that hmm the top are not covered because the rest of them are not covered, why should the bottom be covered if we can make the rest of them not covered?*

Rebuttal

Summary of the argument: Rebuttal+ Counterclaim+ Data+ Claim+ Rebuttal

According to Table 4.2, this is level 3 argumentation.

For research question 1, the transcript above shows that learners do construct arguments because Toulmin's components of an argument were identified. There is a claim, data and a rebuttal. Some of their arguments represent high level as they contain rebuttals. For research question 2, according to the analytic framework table, this argument was at level three because it had one rebuttal. There is a claim that is supported by data. I also saw a rebuttal because it is rebutting the fact that it is not important to cover the bottom part of the containers. According to Erduran et al (2004), an argument that has a clearly identifiable rebuttal is level 3. This is how I used my tool to analyze all my data.

4.2 FINDINGS

Having coded the data using Toulmin's Argument Pattern for 7-1and 7-2, I present my findings in the way in which they answer each of my research questions. My question explored the nature of arguments that learners constructed. To determine this I used the TAP tool to do frequency counts of each of the six components of an argument in each lesson. Table 4.3 below is a summary of the component arguments identified for each class. The table below addresses research question 1 which says:

What is the nature of arguments?

Table 2.3: **Components of arguments identified in the whole class discussion in the two Grade 7 classes.**

Components	**Grade 7-1 Lesson 1**	**Lesson 2**	**Lesson 3**	**Total**		**Grade 7-2 Lesson 1**	**Lesson 2**	**Lesson 3**	**Total**
Claims	7	5	6	**18**		2	7	0	**9**
Data	4	5	6	**15**		4	4	3	**11**
Warrants	1	0	0	**1**		0	1	0	**4**
Backings	0	0	0	**0**		0	0	0	**0**
Qualifiers	0	0	0	**0**		0	0	0	**0**
Rebuttals	0	0	1	**1**		1	0	0	**1**

In whole class discussions I saw 18 claims in one class and 9 in the other, 15 pieces of data in one class and 11 in the other. There were 4 warrants in one class and 4 in the other but there were actually rebuttals in both of them. So the nature of arguments that learners are putting together is that there are making lots of claims using some data but there are making very few warrants and no backings and qualifiers and only 1 rebuttal in all lessons.

This is just for the whole class interaction not for the small groups. The following table therefore presents data on whole discussions and small group discussions for three lessons in 7-1. The same research question was the nature of arguments in group work. There is a difference in the nature of arguments that learners put across during small groups and during whole class discussions.

Table 4.4: Components of arguments identified in whole class discussion and small group discussions in three lessons in 7-1

Components	Lesson 1				Lesson 2				Lesson 3		
	W/ Class	Group 1	Group 2		W/ Class	Group 1	Group 2		W/ Class	Group 1	Group 2
Claims	7	5	9		5	5	8		6	7	4
Data	4	3	2		5	4	4		6	2	4
Warrants	1	0	0		0	0	1		0	0	0
Backings	0	0	0		0	0	0		0	0	0
Qualifiers	0	0	0		0	0	0		0	0	0
Rebuttals	0	0	1		0	0	0		1	0	0

The above table 4.4 shows summary of argument components presented by 7-1 in 3 lessons during whole class discussions and small group discussions and this is what happened. In lesson 1 during whole class discussions 7 claims, 4 pieces of data and 1 warrant no backings no qualifiers. When they broke into groups, one group had 9 claims, 2 pieces of data and 1 rebuttal. The other group had 5 claims and 3 pieces of data only. In lesson 2 when we did whole class it was just claims data and nothing more. The same in group work. In lesson 3 when we did whole class there were claims, data and a rebuttal. In group work there were only claims and data. There is a similar pattern for small groups and whole class. The pattern is more claims, few pieces of data, no backings, no qualifiers, 1 or 2 rebuttals.

Table 4.4 above show that there was more argumentation during small group discussions in lesson 2 group 2 than in group 1 because in group 2 there were 3 argument components whereas in group 1 two argument components were present. There was more data in lesson 2 than in lesson 1 for both groups. This suggests that more learners were discussing in lesson 2 than in lesson 1. Lesson 1 was about an experiment on energy insulation where *the aim was to determine materials that are best insulators*. This is a lesson which requires use of empirical scientific evidence to support claims. The second lesson 2 was about *conservation of heat energy in homes and in buildings*. Learners are familiar with materials that are used to conserve heat in buildings in everyday life situations. Therefore the presence of more pieces of data in lesson 2 than in lesson 1 could suggest that learners produce better quality of argumentation if they are familiar with the content. These findings are in line with a study that was carried out by Braund, et al (2008) which showed high quality arguments in the pure scientific topic and low quality arguments in socio-scientific topic. The quality of arguments is higher in topics that learners are familiar with.
The use of cartoon concept is a stimulus for discussions and this is similar to the findings by Naylor, Keogh and Downing (2006).

In the next table I present argument components in 7-2 in three lessons during whole class discussions and small group discussions.

Table 4.4 shows that in lesson 3 in whole class discussions, 7-1 had 6 claims, 6 data and 1 rebuttal. During small group discussions, group 1 in 7-1, made seven claims and they were only two pieces of data. There were more claims than data for group1 in lesson 3. Group 2 had 4 claims and 4 data. There were no warrants and backings. The two groups in lesson 4 were able to support their claims. There were simple arguments during small group

discussions in lesson 3 during small group discussions. Level 2 arguments were present. Interestingly there was more learner participation as shown by a lot of claims made by group 1 in particular. In this lesson the concept cartoon was used to initiate discussions.

Table 4.5: Components of arguments identified in whole class discussions and small group discussions in three lessons in 7-2

Components	Lesson 1				Lesson 2				Lesson 3		
	W/ Class	Group 3	Group 4		W/ Class	Group 3	Group 4		W/ Class	Group 3	Group 4
Claims	2	8	8		7	4	5		0	3	3
Data	4	2	2		4	4	4		3	8	5
Warrants	0	0	0		1	0	0		0	0	0
Backings	0	0	0		0	0	0		0	0	0
Qualifiers	0	0	0		0	0	0		0	0	0
Rebuttals	1	1	0		0	2	0		0	2	0

Table 4.5 shows summary of argument components presented by 7-1 in 3 lessons during whole class discussions and small group discussions and this is what happened. In lesson 1 during whole class discussions 2 claims, 4 pieces of data and 1rebuttal no backings no qualifiers and no warrants. When they broke into groups, both groups had 8 claims, 2 pieces of data and group 3 had a rebuttal. The other group had 5 claims and 3 pieces of data only. In lesson 2 when we did whole class, it was just claims, data and a warrant. In small groups it was just claims data and 2 rebuttals from group 3. In lesson 3 when we did whole class there were only 3 pieces of data. In group work there were only claims and data. For 7-2 there is a pattern for small groups and whole class. The pattern is that there are more claims, few pieces of data, no backings, no qualifiers, 1 or 2 rebuttals during small group discussions and few claims, data, warrants rebuttals during whole class discussions. The pattern is also similar in that during whole class discussions and small group discussions there are claims, data, warrants and rebuttals occasionally, no backings and no qualifiers.

Notably in all three lessons there was argumentation in both of groups however group 3 had diverse arguments in all lessons more than group 4. In each of the three lessons group 3 had three components of an argument, claims, data and rebuttals while group 4 had only two which are, claims and data. In the three lessons, group 3 achieved level 3 form of argument as compared to group 4 which attained level 2 arguments in all the three lessons so group 3 had better quality of arguments than group 4. Both groups 3 and 4 in 7-2 class were able to engage in argumentation in all three lessons as shown by the presence of supporting evidence in all their lessons.

The table below shows the summary of components of an argument in all three lessons for both classes 7-1 and 7-2 in small group discussions and whole class discussions. This data answers research question 1

Table 4.6: Argument components for all three lessons

Components of the TAP	Frequency																	
	Small groups 7-1 Groups 1 and 2				Small groups 7-2 Groups 3 and 4					Whole class 7-1					Whole class 7-2			
	Lesson 1 Insulation	**Lesson 2** Energy conservation	**Lesson 3** Energy efficiency	**Total**	**Lesson 1** Insulation	**Lesson 2** Energy conservation	**Lesson 3** Energy efficiency	**Total**		**Lesson 1** Insulation	**Lesson 2** Energy conservation	**Lesson 3** Energy efficiency	**Total**		**Lesson 1** Insulation	**Lesson 2** Energy conservation	**Lesson 3** Energy efficiency	**Total**
Claims	14	13	11	**38**	16	9	16	**41**		7	5	6	**18**		2	7	0	**9**
Data	5	8	6	**19**	6	8	14	**28**		4	5	6	**15**		4	4	3	**11**
Warrants	0	1	0	**1**	1	0	0	**1**		1	0	0	**1**		0	4	0	**4**
Backings	0	0	0	**0**	0	0	0	**0**		0	0	0	**0**		0	0	0	**0**
Qualifiers	0	0	0	**0**	0	0	0	**0**		0	0	0	**0**		0	0	0	**0**
Rebuttals	1	0	0	**1**	2	1	2	**5**		0	0	1	**1**		1	0	0	**1**

Table 4.6 represents a total number of argument components in the two classes in all three lessons. Four components of an argument were represented in lesson discussions in both classes. Learners made many claims that were not supported particularly in the first lesson during small group discussions. However it was during whole class discussions when learners provided evidence to support their claims. Whole class discussions presented a platform for the class to discuss assertions made by learners in small groups, correct misconceptions which led to making meaning about science concepts. During the feedback sessions, the rest of the learners questioned claims made by groups that were presenting feedback. Argument lessons improved thereafter. Similarly in a study conducted by Msimanga and Lelliot(2012),whole class discussions led to improved argumentation ability in learners.

There were two patterns in 7-1 and 7-2 during whole class and small group discussions in direct contrast with each other. In 7-2 during whole class discussions learners gave fewer claims and data but in 7-1 learners gave more claims and data. However in 7-2, learners made many claims supported by data, warrants and rebuttals during small group discussions but made only a few claims, data and warrants during whole class discussions. The arguments were different in whole class discussions than they were in small groups and they were different in the two classes.

Notably in all three lessons during small group discussions, 7-1 made 38 claims, 19 pieces of data 1 warrant and 1 rebuttal while 7-2 made a total of 31 claims, 28 pieces of data, 1warrant and 5 rebuttals. Arguably 7-2 had better arguments since most of their claims were supported. During whole class discussions, 7-1had 18 claims, 15 pieces of data, 1 warrant and 1 rebuttal while 7-2 had 9 claims, 11pieces of data, 4 warrants and 1 rebuttal. Lesson 2 in 7-2 had the highest number of warrants than in any other lesson whole class discussions between the two classes.

Having presented data in each of the two classes, I will now compare the two classes. Data for the three lessons was then tabulated to determine the levels of argumentation per group in each class. Lesson 1, 2 and 4 were used for this purpose since these were the lessons where I identified some arguments. In each of the lessons, two questions were selected to establish two episodes per lesson. The episodes were analyzed using the table adapted from Erduran, Simon and Osborne (2004:928) to determine the level of arguments. Components were grouped into combinations. This enabled me to respond to the second research question which seeks to determine the level of argumentation. The following table below shows levels of argumentation in all three lessons for both classes 7-1 and 7-2 for two groups per class.

Learner discussions of the last two questions were transcribed, coded and grouped into combinations according to the TAP.

Data presented on table 4.7 answers research question 2 which is about levels of argumentation. Argumentation describes the process of constructing arguments. Argument components were put together to form combinations such as counterclaims, claims data, data warrants, claims data warrants, claims data rebuttals, claims data rebuttals warrants, claims backings data warrants. This data was then used to determine the levels of argumentation using an analytic framework by Erduran et al (2004). Table 4.7 shows the levels of argumentation.

Table 4.7: Levels of argumentation

Grade 7-1							Grade 7-2				
Levels	Combinations of argument Components	Lesson 1	Lesson 2	Lesson 3	**Sub total**	**Total**	Lesson 1	Lesson 2	Lesson 3	**Sub total**	**Total**
1	CC	4	2	3	**9**	**9**	5	4	4	**17**	**17**
2	CD	4	4	3	**11**	**14**	4	4	1	**9**	**15**
	DW	0	2	0	**2**		1	1	1	**3**	
	CDW	1	0	0	**1**		1	2	1	**3**	
3	CDR	1	0	0	**1**	**1**	2	0	1	**3**	**3**
4	CDRW	0	0	0	**0**	**0**	0	0	0	**0**	**0**
5	CDBR	0	0	0	**0**	**0**	0	0	0	**0**	**0**

In lesson 1 in both classes level 4 and 5 argumentation was not there. Argumentation was only up to level 3. Most learner argumentation was at level 2 for both classes. There were 14 and 15 level 2 arguments as compared to 1 and 3 level 3 arguments. However, 7-2 had many level 1 arguments. Essentially 7-2 made many more arguments than 7-1 because 7-2 had 35 permutations while 7-1 had 24 different permutations. Class 2 (7-2) made more arguments than class 1 (7-1) but they made many at level 1. At level 2 they are more or less the same. At level 3 they do have 2 more than class 1. Class 2 is richer in terms of diversity than class 1. They made many low level and they were making second level and a few at third level. Whereas class 1 they made fewer at level 1 some level 2 and very few level 3.

Two graphs are derived from table 4.7 for both classes Grade 7-1 and Grade 7-2 showing combinations of argument components in three lessons.

Figure1 Permutations of argument components for 7-1

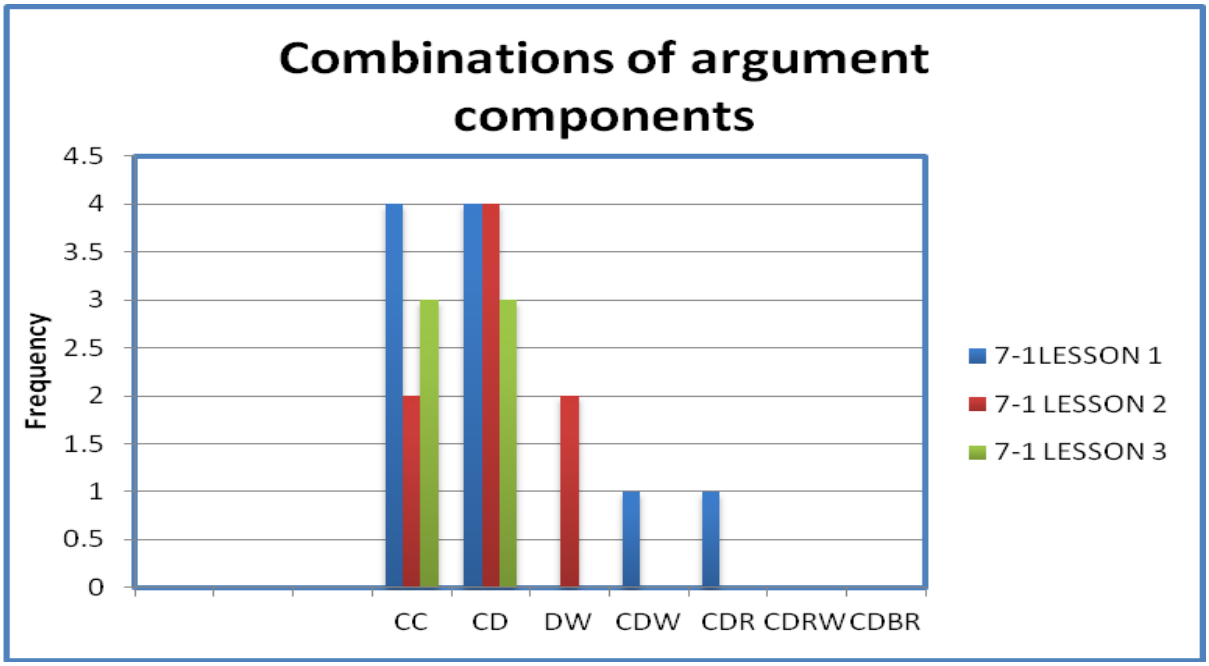


Figure 1 shows that in lesson 1, Grade 7-1 learners made the most unsupported claims and that is the only lesson with a warrant. There were 4 counter claims, 4claims and data and 1 claim, data and warrant component and 1 claim data rebuttal. In lesson 1 there were simple arguments at level 2. Lesson 2 had only two combinations. There were 3 counter claims and three pieces of data were provided. The last lesson had 2 counter claims, 4 claims and data

and 2 pieces of data and warrant. Figure 2 below shows a summary of the three lessons in 7-2.

Figure 2 Permutations of argument components for 7-2

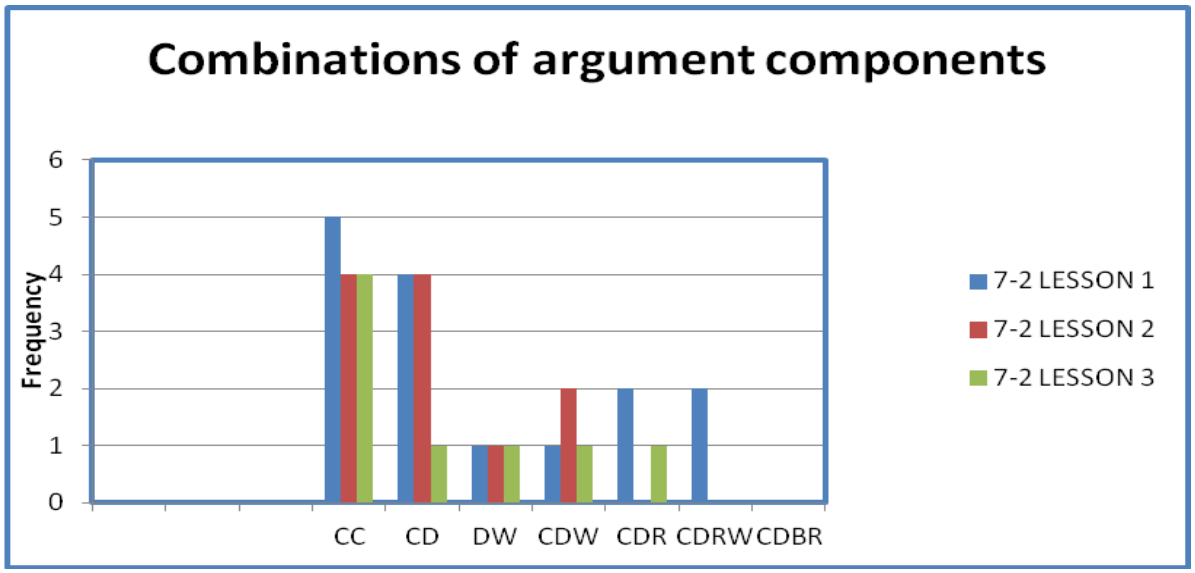


Figure 3 shows the frequencies of each combination of argument components for 7-2. In lesson 1, there were 5 counter claims, 4 claims and data, 1 data and warrant, 2claims, data and rebuttals. Four components of argumentation were present. The last two lessons had four components of argumentation. There were many unsupported claims in lesson but there were four argument components (claim, data, rebuttal and a warrant). Interestingly I saw increased participation for both classes in lesson 1 than in any other lesson. Perhaps it was a more amenable lesson to argumentation than the other lessons. Seemingly when learners are familiar with content they are bound to participate more unlike when the content is unfamiliar. Similarly in Zohar and Nemet (2002) in their study, learners were able to formulate arguments because they had learnt about genetics.

In the next section, I present my findings from qualitative data on how learners used evidence to support their arguments in the two classes during the science lessons. The findings below are a response to research question 3.

4.3 PRESENTATION OF QUALITATIVE DATA

I will discuss what was happening in the groups in relation to the type of evidence given by learners to support their claims in response to research question 3. Learners provided many simple arguments in level 2 which had some justifications of claims but no evaluation of reasoning behind it. Learners also produced a few high level arguments with rebuttals. For instance in Grade 7-2 there were 4 rebuttals in groups 1 and 2. This is inconsistent with Zohar and Nemet (2002) findings that even before instruction most learners can formulate arguments, and rebuttals but these arguments tend to be simple, consisting of only one justification and have a simple structure. Below is an example of a simple argument:

Is it important that each of the containers had the same amount of hot water in? Explain why this is so.

Nozi: *That way it is easy to identify the temperature.* ***Claim***

Dave: *If we don't have equal amount of water, we are not going to have accurate results.* ***Data***

Summary of the argument: Claim + Data *Appendix 1a.*

In some instances arguments were built up of inaccurate scientific knowledge yet they are still considered as argument according to TAP analysis (Toulmin, 1958). The TAP analysis only dwells on the logical use of evidence to support or refute claims. The TAP does not allow for the analysis of the accuracy of science content used in argument construction. To further analyse the nature of evidence I had to turn to Zohar and Nemet (2002), who used a different tool to analyse scientific arguments. Zohar and Nemet (2002), maintain that good arguments are those arguments in which conclusions are supported with accurate specific scientific knowledge. They further allude that good arguments could be strengthened by the use of multiple justifications comprising relevant and accurate scientific information.

Here is an example of one of the instances where learners provided arguments that had inaccurate scientific evidence: **Appendix 2b**

Is it important that each of the containers had the same amount of hot water in it?

3 ***Luntu:*** *I think we have to take it in different ways because the hotness of the water goes with amount of water.* ***Claim***

4 ***Tom:*** *I don't think it is important because we recording the temperature of water not the amount of water.* ***Counter Claim***

5 ***Luntu:*** *But Tom if you put small ice it will melt quickly but if you put a bigger one it won't melt quickly.* ***Rebuttal***

6 ***Tom:*** *Ok like let's focus on water when you pour like in each cup but the water is not equal I think it won't change anything man.* ***Claim***

Sphiwe: *I think it will.* ***Counter Claim***

7 ***Tom:*** *No we not measuring the amount of water, we measuring the temperature.* ***Data***

8 ***Sphiwe:*** *I also don't think it will coz you are measuring the temperature not the amount of water.*

9 ***Luntu:*** *Ya now I get your point, because it's like when you put tea in two different cups then when you measure the temperatures will be same.* ***Data***

10 ***Tom:*** *It's not like you put cold water in one cup and you put boiled water in another cup, you put boiled water in both cups so the temperature will be the same, so it isn't important.* ***Claim/Data***

11 ***Sphiwe:*** *But then it says explain why this is so? It means that it is unfair*

12 ***Luntu:*** *If the question had said that if yes explain and if no don't explain.*

13 ***Tom:*** *So it is important.*

14 ***Luntu:*** *Because it says explain why it is so then the answer is yes*

15 ***Sphiwe:*** *The one that is small is gonna cool faster than the one that is full.* ***Claim***

16 ***Tom:*** *I think you are right: so we will say the smaller the amount of water the faster it will take to cool down and the bigger the amount of water in a container the longer it will take to cool down.* ***Data***

Summary: ***Claim+ Counter Claim+ Rebuttal+ Claim+ Counter Claim+ Data+ Data+ Claim+ Data + Claim + Data.***

The group is uncertain about their answers and they provide evidence in form of data which is not correct scientifically when Tom says: "*I don't think it is important because we*

recording the temperature of water not the amount of water" (lines 6 and 7). He suggests that the amount of water is not important in the experiment which is incorrect. Sphiwe initially supports the faulty line of thought by giving incorrect evidence in line 9 when she says "*I also don't think it will coz you are measuring the temperature not the amount of water."* Luntu further defends the fact that the amount of water does not matter in the experiment when she says in line 10, "*Ya now I get your point, because it's like when you put tea in two different cups then when you measure the temperatures will be same."* The three learners all give evidence which is incorrect scientifically. In the experiment conducted in the lesson, water is a fixed variable. Once a fixed variable is changed the experiment is deemed not to be a fair test and incorrect results are obtained. Luntu then thinks otherwise and says, *" But Tom if you put small ice it will melt quickly but if you put a bigger one it won't melt quickly."* She provides a warrant in trying to explain her position. The argument is logically wrapped up by Sphiwe the group leader, who provides campus to the discussion and gives accurate data. Here is another example of incorrect evidence that was given.

What forms of energy is wasted energy? Appendix 2f

2	***Sphiwe:*** *Light energy, kinetic energy, sound energy when they are crushing coal.*	***Claim***
3	***Tom:*** *Also put heat energy.*	***Claim***
4	***Sphiwe:*** *Heat is not wasted, oh yes heat is wasted.*	***Counter claim***
5	***Tom:*** *How can heat be wasted when it is used to boil the water producing steam needed to drive turbines?*	***Data***
6	***Nkosi:*** *Guys heat is wasted.*	***Claim***
7	***Sphiwe:*** *It needs the blaze.*	***Data***

Summary of the argument: Claim + Claim + Counter claim + Data + Claim + Data

The above discussion shows some inconsistencies in the argument. Firstly the idea of heat as one of the wasted energy is mentioned in **line 3-5** then rejected and later on adopted without further evidence to support its adoption **(line 6).** It is eventually not considered as wasted energy as implied by the final argument. Heat energy is actually one of the wasted forms of energy during the production of electricity in a thermal power station because not all heat is directed to the heating of water in the boilers. Some of it is lost along the process. Below is another example of incorrect evidence:

What is the benefit of having a ceiling as a roof? Appendix1d

2 Gugu: *Guys what would happen if we don't have a ceiling?*

3 ***Len:*** *We get heat.* ***Claim***

4 ***Chris:*** *We are going to be poured by rain.* ***Claim***

5 ***Gugu:*** *To prevent heat and rain above.* ***Claim+Data***

6 ***Gugu:*** *Ceiling traps air ensuring reduction the heat flow into and out of the house.*

Data+Warrant

Summary of the argument=Claim+Claim+Claim+Data+Data+Warrant

The discussion begins when the two learners Len and Chris make claims. Chris's claim, suggests that if there is no ceiling the rain can go through the roof and this is incorrect. Gugu (**in line 5**) supports Chris claim. It is not clear what makes her give a different piece of evidence which is adopted without questioning.

However not all arguments were flawed with incorrect scientific evidence during small group discussions. Here is an example:

Why should the bottoms of the containers be covered? Appendix1

2 ***Gugu:*** *Because, you know the cup if we don't cover the bottom of the cup the heat is gonna come out fast.* ***Claim +Data***

3 ***Chris:*** *To prevent heat from the cold air.* ***Claim***

Summary of argument: Claim+Data+Claim

In this short discussion, Gugu makes a claim and supports it with data which is just personal reasoning which seemingly is correct. On the other hand Chris also makes a claim. Even if these learners are not giving scientific evidence, they are giving correct reasoned evidence to support their claims. Below is one example where learners use correct scientific evidence during small group discussions.

Is it important that each of the containers had the same amount of water in it? Appendix 2a

17 ***Senzo:*** *I think the glasses should have the same amount of water because it It won't be a fair experiment if the water is cool or hot all of them should be the same.* ***Claim + Data***

18 ***Ben:*** *I think it is important for the containers to have the same amount of water because when you are doing an investigation all the variables should be the same including the amount of water.* ***Data + Warrant***

19 ***Ben:*** *It is important because you want to have a fair test.* ***Data***

Summary of the argument: Claim + Data + Data + Warrant + Warrant

The above argument contains several scientifically correct justifications. Good arguments could be strengthened by the use of multiple justifications comprising relevant and accurate scientific information (Zohar and Nemet,2002). For the results of an experiment of such a kind to be correct, the amount of water has to be the same in each container and this leads to a fair test. Water is one of the variables that need to be constant. Grade 7-1 had one argument which had scientifically correct justifications from group 2 lesson 1, while grade 7-2 had three very good arguments of which two were given by group 1 lesson 1 and one was from group 2 in lesson 1. The three arguments from 7-2 were level 3. For learners who were not tutored in argumentation, the ability to provide rebuttals for each other's is unusual. In a study of a similar group of learners in the Western Cape, Lubben and his colleagues reported low levels of the kind of evaluative engagement necessary for the provision of rebuttals for their peers (Lubben et al., 2009).

I will now discuss common trends in argumentation that emerged from the different groups during the lessons.

GROUP ARGUMENTATION PATTERNS

There were common patterns that were found to be characteristic and influenced the argumentation interactions during classroom discussions. These include patterns of learner participation, learner engagement with concepts and avoiding unfamiliar concepts.

4.3.1 PATTERNS OF LEARNER PARTICIPATION

Some of the small groups that had learners who spoke more frequently than others and such learners provided high quality arguments with rebuttals and warrants. Group 1 in 7-2 consisted of boys only. This group was constituted by two learners who were actively engaged in discussions and two learners who were passive and seldom spoke. The transcript below is an example of the nature of arguments that happened in such small groups. **Appendix 2a.**

Why should the bottoms of the containers also be covered?

3 ***Senzo:*** *All the containers must be covered because heat can be lost under the container.* ***Claim***

6 ***Ben:*** *Why is that the bottom has to be covered because the top is not covered?*

7 ***Senzo:*** *The top is not covered because we cannot where would we put the thermometer sit?* ***Claim***

8 ***Ben:*** *Will that make the investigation correct?*

9 ***Senzo:*** *Yes because the rest of them are not covered.* ***Claim***

10 ***Ben:*** *But if you say that hmm the top are not covered because the rest of them are not covered, why should be the bottom be covered if we can make the rest of the bottom not covered?* ***Rebuttal***

11 ***Senzo:*** *Because that's where the thermometer will come in.*

12 ***William:*** *Hmm wait Senzo the last answer you gave is that the top must be open because the rest of them are open ok, why should the bottoms be covered if the rest of them are not covered? Why?*

13 ***Senzo:*** *Because the glass is going to be put on top of another material, heat is going to be transferred from the glasses to the other materials.* ***Claim/Data***

14 ***Ben:*** *Hmm it's gonna be put on top of other materials and heat can be lost I get it.*

15 ***Senzo:*** *Yes because you can't hold the glass.*

16 ***Ben:*** *The bottoms of the containers should also be covered because the glass should not be in contact with another material.* ***Warrant***

Summary: Claim + Claim + Claim + Rebuttal + Claim + Data + Warrant

The discussion above opens through a claim that containers must be covered because heat can be lost under the container. Ben is not satisfied and he interrogates the claim further (line 10). Senzo keeps making claims of which has nothing to do with science evidence when he says

that, "*The top is not covered because we cannot where would we put the thermometer sit?" (line 7),* Ben rebuts the claim until Senzo provides a warrant with scientific data when he says, ***"****Because the glass is going to be put on top of another material, heat is going to be transferred from the glasses to the other materials"(line 12).* The statement suggests that, if the containers are not covered some of them would quickly lose heat to the objects they are placed on through conduction. Arguments with a claim, data, warrant and a rebuttal are level 3 arguments (Erduran et al, 2004). This is a good quality argument since learners were able to give scientific evidence to claims. These results are synonymous with findings by Means and Voss (1996).

In their study Means and Voss (1996) observed that gifted learners performed better than average or below- average learners on most of every measure of argumentation ability tested. Learners who are intelligent are able to help other learners during small group discussions to make sense of concepts under discussion. Although gifted learners help to provide good quality arguments by giving scientific evidence they tend to dominate other group members. The above discussion was left to two learners who were active participants and dominated the whole discussion while the other two learners were relegated to mere listeners. The dominance of some learners during small group discussions was evident in both classes 7-1 and 7-2. Argumentation is meant to promote learner engagement so that every learner can make own meaning of concepts. There were indications that learner engagement with concepts has influence in argumentation.

4.3.2 LEARNER ENGAGEMENT WITH CONCEPTS

Learners did not engage much with concepts they were not familiar with and in some instances they gave scientifically incorrect supporting evidence to their claims. They also gave claims not supported by data such as in the extract below: **Appendix 1d**

Is it important that each of the containers had the same amount of hot water in it? Explain why this is so.

7 ***Bobo:*** *Yes because we have to protect the temperature.* ***Claim***

8 ***Gugu:*** *I think no, Sir didn't pour the same amount, he just put water.* ***Claim, Counter Claim, Data***

9 ***Len:*** *Yes he did.* ***Claim***

Chris: *He measured it.* ***Claim***

The above discussion is a simple argument which has no justification at all to claims. This does not amount to a valid argument (Erduran et al, 2004) because learners simply gave

claims and counter claims due to lack of content knowledge. Means and Voss (1996) found that knowledge is related to some aspects of argumentative thinking such as generating more reasons or stating more qualifiers, but not to other aspects. Where learners have content knowledge or prior knowledge, they make quality arguments. They are able to give more warrants that support their assertions. In their study, Zohar and Nemet (2002) learners were able to formulate good quality arguments with rebuttals because they had prior knowledge to the topic. Content knowledge therefore is critical in argumentation. Learners need to be familiar with concepts in order to give correct scientific evidence.

4.3.3 AVOIDING UNFAMILIAR CONCEPTS

If learners are not familiar with the concepts, they will give incorrect evidence. Here is another example**: Appendix 2c:**

In the drawing of the energy efficient house shown in this lesson, list the features that you can see that are good design features.

Ben: *The roof of the house and the ceiling minimises heat loss that's why the house maybe cooler in summer and warmer in winter.* ***Data***

Menzi: *Cement, concrete bricks, building materials, the ceiling.* ***Claim***

Some houses are cool in summer while others get hot inside in summer. Do you agree or disagree? Give reasons.

Menzi: *Umm they are all hot in summer.* ***Claim***

Ben: *No it's not true because some houses that are not built using insulating materials are hot inside in summer and cold during winter.* ***Data***

The above discussions show that Menzi lacks consistency in his answers. First he gives correct answer about good design features that make a building to be energy efficient (line 6). In line 7, he believes that all houses have the same temperature whether they have good design features or not. The concept of thermal mass and thermal insulation, seem not to have been understood by Menzi. He is not able to defend his view.

4.4 CONCLUSION

The analysis and discussions in this chapter have shown that grade 7 learners who are untutored in argumentation are able to engage in argumentation. However most of the learners can only engage in simple arguments at level 3. During whole class discussions learners could not offer rebuttals, claims and data to their peers but during small group discussions they started giving some rebuttals even though some rebuttals were weak. The use of small groups presents a platform for learner engagement if the learners are carefully

selected in terms of performance. The whole class discussion method can serve as a strategy for learners to further provide warrants and interrogate incorrect evidence used to support the claims and scaffold learning. There were more warrants during whole class discussions as compared to small group discussions. Whole class discussions help to harness different views which learners may harbor. There were more rebuttals in small group discussions than in whole class discussions. Conclusions and recommendations follow in the next chapter.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

This chapter begins with the general summary of the findings and conclusions that are drawn in relation to the research questions of this study. These are followed by the recommendations and limitations of the study.

5.1 GENERAL SUMMARY OF THE FINDINGS

In this research report I have shown how I used different tools to analyse captured data in order to respond to my research questions. Firstly, I used Toulmin's Argument Pattern (TAP) to analyse the structure of learner arguments from both whole class and small group discussions. I then explored the level of argumentation by using the analytic framework adopted from Erduran et al, (2004). The findings suggest that learners in each class were able to formulate arguments, counter arguments and some (weak) rebuttals. However, most of these arguments tended to be simple consisting of many unsupported claims **(see table 4.5.1 and 4.5.2).** A few arguments presented consisted of only one justification in form of data.

A comparison between the two classes, Class 1(Grade 7-1) and Class 2 (Grade 7-2) revealed that Class 1 made more claims and supported them with more pieces of data in whole class discussions, than Class 2, while Class 2 made more claims and supported them with more pieces of data during small group discussions than did Class 1. This suggests during whole class there is something happening with 7-2 which makes it more difficult for learners to make claims or support them with data but when they are in small groups they can. In 7-1 the learners seem to be able to make and support claims whether it is in whole class discussion or in small group work. There is therefore need to find out why in some classes learners give fewer claims and data during whole class discussions but give more claims and data during small group discussions.

In terms of levels of argumentation, I found out that groups provided unsupported claims classified as level 1 argument (**see appendix 1a and 2a)** with the exception of 2 groups in which there was a higher level of argumentation with warrants and rebuttals, at level 3 (**see appendix 2a and 2b).** There was argumentation only up to level three and most learner argumentation was at level 2. There was no argumentation at level 4 and 5. Class 2 (Grade7-2) had a higher diversity of arguments. They argued at all levels one, two and three. Whereas

7-1 made very few at level 1, some in level 2 and very few in level 3. Lesson 1 is the only lesson where there were warrants and rebuttals provided out of all the three lessons for 7-1.

Finally to respond to my third research question on the nature of evidence used to support arguments, I drew from Zohar and Nemet (2002) ideas although I did not use their analytic tool per (se). Zohar and Nemet (2002), maintain that good arguments are those arguments in which conclusions are supported with accurate specific scientific knowledge. They argued that when claims are interrogated by fellow members of the group, the learners who made claims eventually provided warrants that were based on scientifically correct evidence to support their assertions. In such groups this led to learning taking place. Zohar and Nemet (2002) further allude that good arguments could be strengthened by the use of multiple justifications comprising relevant and accurate scientific information. In my study, there were scientific evidence in different ways **(**see **Appendix 2a)**, For example there was a question which required learners to justify the need to cover the bottom part of the containers when filled with hot water. After presenting their arguments, learners were able to argue that covering the bottom part of the containers, is meant to avoid conduction which is an external factor that could interfere with the experiment leading to inaccurate results. In one South African study, Lubben et al (2009) reported low level argumentation by grade 10 untutored learners at levels 1 and 2. In my study, some of the Grade 7 learners were able to argue at level 3 although they are untutored in argumentation (**see appendix 2a)**. This is an indication of the potential for learners who are untutored in argumentation to learn science through argumentation.

5.3 CONCLUSIONS

The findings of this study have shown that untutored learners taught by a tutored teacher are able to engage in argumentation even if it is at low levels. Most of these arguments are simple arguments that consist of claims and data. However some learners are able to construct good arguments using rebuttals even if they may not be scientifically correct. It is therefore important for teachers to focus on helping learners use scientific evidence to defend their assertions. There is a need to scaffold their argumentation by providing tools and content that will help learners provide scientific evidence. Methods like concept cartoons and data cards could be used especially to primary school learners.

Learners who can make and support arguments are also able to make meaning of science concepts. When learners are able to provide many qualifiers, warrants and alternative views through rebuttals, then they can learn even better.

5.4 RECOMMENDATIONS

The main purpose of science education is to develop learners' ability to understand science concepts (Gilbert & Reiner, 2000). In this study learners were able to engage in argumentation in order to understand science concepts. My findings show that learners can present high quality arguments even though are untutored in argumentation during small group and whole class discussions. I therefore recommend further study of how argumentation can be used as one of the instructional strategies that promotes discussion.

Teacher professional development could also focus on making teachers competent in argumentation and this may translate into teaching that fosters learner argumentation even if the learners themselves are not specifically tutored. The use of argumentation as a teaching strategy could help address the challenges of poor performance in science by learners.

Further research might inform teacher education and classroom argumentation in constrained environments where learners are generally untutored as is the case in many South African classrooms.

5.5 LIMITATIONS OF THE STUDY

The findings of this study cannot be generalized since the research was conducted in a single primary school in Johannesburg.

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APPENDIX: 1a

GRADE 7-1 LESSON TRANSCRIPTS

TRANSCRIPTION OF DATA	
NAME: T.MOYO	
CLASS: GRADE 7-1	
Topic: *Insulation and energy saving: Experiment*	
Lesson 1 Group 1	
Small group discussion:	
Why must all the containers used be identical?	
Dudu: So that they have the same amount of temperature. **Dave:** So that they keep same temperature.	**C**
Dudu: It cannot be the same. So that they can give us the correct type of temperature.	**C** **C/D**
Why should the bottoms of the containers also be covered?	
Dudu: They should be covered because they temperatures should be the same.	**C/D**
Dave: So that the heat must not escape from the glass.	**D**
Is it important that each of the containers had the same amount of hot	

water in it? Explain why this is so.	
Sesi: Yes	**C**
Dudu: So that	
Whole class discussion- feedback	
Why must all the containers used be identical?	
Gugu: Sir if use the different containers we won't get the same temperatures.	**C**
Nozi: So that it will be easy to identify containers.	**C**
Dave: To get an accurate answer.	**C**
Why should the bottoms of the containers also be covered? **Nozi:** We think it is important to maintain the temperature	**C**
Dave: So that it doesn't lose heat easily.	**D**
Mary: It must show the actual temperature.	**D**
Dave: To prevent heat loss.	**C**
Teacher: Imagine that the bottom part of the container is not covered and the surface where we put our container is a metal, what would happen?	
Mavis: The surface will get hot and conduct heat from the container.	**C/D**

Class: We won't get the accurate temperature.	**C**
Is it important that each of the containers had the same amount of hot water in it? Explain why this is so.	

Teacher: Those who are saying yes what is the explanation?	
Nozi: That way it is easier to identify the temperature.	**C**
Teacher: Yes but it is not properly articulated.	
Dave: If we don't have equal amount of water we are not going to get accurate results.	**D**
Teacher: That is a brilliant answer. He brought another idea that in a glass which is full heat loss is more than in a glass which is not full. Is that so?	

APPENDIX: 1b

TRANSCRIPTION OF DATA	
NAME: T.MOYO	
CLASS: GRADE 7-1	
Topic: *Insulation and energy saving: Experiment*	
Lesson 1 Group 2	
Small group discussion:	
Why must all the containers used be identical?	
Gugu: Because we should get the same temperature.	**C**
Chris: Ekodi you don't get the same temperature. **Gugu:** When the glasses are not the same.	**R** **C**
Chris: No	
Why should the bottoms of the containers also be covered?	
Gugu: Because, you know the cup if we don't cover the bottom of the cup the heat is gonna come out faster.	**C/D**
Chris: To prevent heat from the cold air.	**C**
Is it important that each of the containers had the same amount of hot water in it? Explain why this is so.	
Bobo: Yes because we have to protect the temperature.	**C**
Gugu: I think no, Sir didn't put the same amount, he just put water	**C/C/D**
Len: Yes he did.	**C**

Chris: He measured it.	**C**
Gugu: Sir but you never put the same amount of water	
Teacher: I did pour water in all the glasses to the level of the last line to ensure that there was the same amount of water.	
Gugu: So the answer is yes that we get the same amount of temperature.	**C**
Whole class discussion- feedback	
Why must all the containers used be identical?	
Gugu: Sir if use the different containers we won't get the same temperatures.	**C**
Nozi: So that it will be easy to identify containers.	**C**
Dave: To get an accurate answer.	**D**
Why should the bottoms of the containers also be covered?	
Nozi: We think it is important to maintain the temperature	**C**
Dave: So that it doesn't lose heat easily.	**D**
Mary: It must show the actual temperature.	**C**
Dave: To prevent heat loss.	**C**
Teacher: Imagine that the bottom part of the container is not covered and the surface where we put our container is a metal, what would happen?	
Mavis: The surface will get hot and conduct heat from the container.	**D/W**
Class: We won't get the accurate temperature.	**C**
Is it important that each of the containers had the same amount of hot water in it? Explain why this is so.	
Teacher: Those who are saying yes what is the explanation?	

Nozi: That way it is easier to identify the temperature.	**C**
Teacher: Yes but it is not properly articulated.	
Dave: If we don't have equal amount of water we are not going to get accurate results.	**D**
Teacher: That is a brilliant answer. He brought another idea that in a glass which is full heat loss is more than in a glass which is not full. Is that so?	

APPENDIX: 1c

TRANSCRIPTION OF DATA	
NAME: T.MOYO	
CLASS: GRADE 7-1	
Topic: *Conservation of heat in homes and buildings*	
Lesson 2 Group 1	
Small group discussion:	
Which direction should a house face in this country?	
Dudu: Houses should face north in this country.	**C**
Why should they face this way?	
Sesi: To gain maximum heat from the sun and for effective solar collection	**D**
What is the benefit of having a ceiling in the roof?	
Bongi: Ceiling traps air ensuring a reduction of heat flow into and out of the house.	**C/D**
How does the position of the sun change in winter and in summer?	
Dudu: This shades the house in summer when the sun is high in sky and allows in the house in winter when the sun is much lower.	**C/D**

In the drawing of the energy efficient house shown in this lesson, list the features that you can see that are good design features.	
Dave: A ceiling, wooden window frames, glazed window glasses, hollow cement blocks, concrete flooring	**C**
Some houses are cool in summer while others get hot inside in summer. Do you agree or disagree or disagree? Give reasons.	
Bongi: We agree neh	
Dudu: Yes we agree because the house is warmer in winter and cooler in summer so ceiling traps air ensuring a reduction of heat flow into and out of the house.	**C**
Do you think indigenous houses are energy efficient? Explain your answer.	
Dave: The houses in South Africa are made of clay and thatch and these materials are energy efficient	**C/D**
Whole class discussion	
Which direction should houses face in the country?	
Mary: North	**C**
Why should they face this way?	
Mavis: They should face this way so that they gain maximum heat from the sun.	**D**
What is the benefit of having a ceiling in the roof?	
Nozi: Ceiling traps air ensuring a reduction of heat into or out of the house.	**C/D**
How does the position of the sun change in winter and in summer?	
Sesi: This shades the house in summer when the sun is high in the sky and allows the sunlight into the house in winter when the sun is much lower.	**C**
In the drawing of the energy efficient house shown in this lesson, list the features that you can see that are good design features.	
Mavis: The wooden window frames and an overhang	**C**

Teacher: How do they help?	
Dudu: These materials such as bricks have thermal mass.	**D**
Some houses are cool in summer while others get hot inside inside in summer. Do you agree or disagree or disagree? Give reasons.	
Sesi: We agree because some houses are built differently and with different materials.	**C/D**
Do you think indigenous houses are energy efficient? Explain your answer.	
Dave: Yes they use thatching grass as a roof and thatching grass is a thermal insulator.	**D/W**

APPENDIX: 1d

TRANSCRIPTION OF DATA	
NAME: T.MOYO	
CLASS: GRADE 7-1	
Topic: *Conservation of heat in homes and buildings*	
Lesson 2 Group 2	
Small group discussion:	
Which direction should a house face in this country?	
Chris: In South Africa, they should face east.	**C**
Gugu: Aah they should face north	
Why should they face this way?	
Gugu: So that it should benefit heat from sun.	**D**
Chris: So that it should benefit heat or conduct heat from the sun	**D**
Gugu: Look so that it gets maximum benefit from the sun.	**C**
Chris: Which sun?	
Gugu: There is only one sun.	
Why should they face this way?	
Gugu: I am not sure so that it can benefit maximum energy from the sun.	C
What is the benefit of having a ceiling as a roof?	
Gugu: Guys what would happen if we don't have a ceiling?	
Len: We get heat	**C**

Chris: We were going to be poured by rain	**C**
Gugu: To prevent heat and rain from above.	**C**
Gugu: ceiling traps air ensuring reduction the heat flow into and out of the house.	**D/W**
How does the position of the sun change in winter and in summer?	
Gugu: In winter the sun	
In the drawing of the energy efficient house shown in this lesson, list the features that you can see that are good design features.	
Gugu: The windows, the doors.	**C**
Some houses are cool in summer while others get hot inside inside in summer. Do you agree or disagree or disagree? Give reasons.	
Gugu: Yes because some houses are made of thatch and thatch is an insulator.	**C/D**
Do you think indigenous houses are energy efficient? Explain your answer.	
Whole class discussion	
Which direction should houses face in the country?	
Mary: North	**C**
Why should they face this way?	
Mavis: They should face this way so that they gain maximum heat from the sun.	**D**
What is the benefit of having a ceiling in the roof?	
Nozi: Ceiling traps air ensuring a reduction of heat Flow into or out of the house.	**D/W**
How does the position of the sun change in winter and in summer?	

Sesi: This shades the house in summer when the sun is high in the sky and allows the sunlight into the house in winter when the sun is much lower.	**C/D**
In the drawing of the energy efficient house shown in this lesson, list the features that you can see that are good design features.	
Mavis: The wooden window frames and an overhang	**C**
Teacher: How do they help?	
Dudu: These materials such as bricks have thermal mass.	**D**
Some houses are cool in summer while others get hot inside in summer. Do you agree or disagree or disagree? Give reasons.	
Sesi: We agree because some houses are built differently and with different materials.	**D**
Do you think indigenous houses are energy efficient? Explain your answer.	
Dave: Yes they use thatching grass as a roof and thatching grass is a thermal insulator.	**D/W**

APPENDIX: 1e

TRANSCRIPTION OF DATA	
NAME: T.MOYO	
CLASS: GRADE 7-1	
Topic: *Energy efficiency in power stations*	
Lesson 3 Group 1	
Small group discussion:	
Write three sentences to explain how a coal- fired power station makes electricity	
Dudu: Burning coal is used to heat water, then the steam drives the turbines and turbines drive the generator which makes electricity.	**D**
Fill in the percentage of energy input, percentage loss and the percentage of the energy out for a power station. Also name the types of energy at each point.	
Bongi: The energy that comes out kinetic energy,	**C**
Dudu: No there must be another type of energy.	
Teacher: That diagram is asking you to tell us what is the input energy?	
Sesi: It's a kinetic energy sir.	**C**
Teacher: What do we use to generate electricity?	
Bongi: Boiling water.	**C**
Dudu: Percentage input is 50% output 25%	**C**
What forms energy are wasted energy?	

Dave: heat energy only	C
Suggest two ways in which energy could be used in a power station	
Dudu: Use the waste to heat to make fuel.	**C**
What are green house gases?	
Sesi: Greenhouse gases are carbon dioxide.	**C**
Dave: Block heat in the atmosphere and reflect it back to earth	**D**
How do power stations impact on the environment? **Dudu:** What's the meaning of impact sir?	
Teacher : What do the power stations do to the environment?	
Dudu: Waste powered power stations would help by environmentally by easing the problem of overfull landfills.	**C**
Whole class discussions.	
Write three sentences to explain how a coal- fired power station makes electricity.	
Mavis: Burning coal is used to heat water until it produces steam. The steam produces energy that drives the turbines. Kinetic energy of the turbines is converted into electricity.	**D**
Fill in the percentage of energy input, percentage loss and the percentage of the energy out for a power station. Also name the types of energy at each point.	
Mavis: Input coal that's 50% output electricity 50% then the energy loss is 25%	**C**
Mavis: You know why I say it's25% sir, because it says this means that half of the energy in the coal is lost as heat and light and other forms of energy.	**D**
Teacher: She doesn't agree with you.	
Gugu: It says 50% is input and then 50% is output and then now where does the 25% come from?	**R**
Mavis: Fom the energy in.	**C**
Teacher: Generally it's supposed to be input **Gugu:** 100%	**D**
Mary: Energy output 50% because energy output is always less than input	**C/D**

energy and energy loss is 50%	
What forms energy are wasted energy?	
Gugu: Heat and light energy.	**C**
Teacher: The other forms	
Class: like sound, kinetic	**D**
Suggest two ways in which energy could be used in a power station	
Mavis: Use the waste to heat the buildings or combine coal with other types of fuel such as natural gas.	**C**
What are green house gases?	
Nozi: Gases like carbon dioxide, sulphur dioxide released to the atmosphere add to the problem of climate change.	**C/D**
How do power stations impact on the environment? **Chris:** Coal pollutes the environment.	**C**

APPENDIX: 1f

TRANSCRIPTION OF DATA	
NAME: T.MOYO	
CLASS: GRADE 7-1	
Topic: *Energy efficiency in power stations*	
Lesson 3 Group 2	
Small group discussion:	
Write three sentences to explain how a coal- fired power station makes electricity	
Gugu: Burning coal is used to heat water, the steam drives the turbines and kinetic energy from the turbines is converted into electricity by generators.	**D**
Fill in the percentage of energy input, percentage loss and the percentage of the energy out for a power station. Also name the types of energy at each point.	
Gugu: Energy in is coal and energy out is electricity and energy out is the heat **Chris:** What does the question say?	**C**
Gugu: You were not listening. Energy out is the heat and light energy.	**C**
What forms energy are wasted energy?	
Gugu: heat energy and light are other forms of energy wasted	**C**
Suggest two ways in which energy could be used in a power station	
Gugu: To use the waste to heat the buildings in the nearby district. To use waste matter from landfill site as fuel.	**D**
What are green house gases?	
Gugu: A lot of carbon dioxide and sulphur dioxide released into the atmosphere. These are greenhouse gases.	**D**

How do power stations impact on the environment? **Len:** I think its smoke. **Gugu:** The results of burning air, is one of the biggest problems of making electricity from coal because these gases pollutes the air.	**C** **D**
Whole class discussions.	
Write three sentences to explain how a coal- fired power station makes electricity.	
Mavis: Burning coal is used to heat water until it produces steam. The steam produces energy that drives the turbines. Kinetic energy of the turbines is converted into electricity.	**D**
Fill in the percentage of energy input, percentage loss and the percentage of the energy out for a power station. Also name the types of energy at each point.	
Mavis: Input coal that's 50% output electricity 50% then the energy loss is 25%	**C**
Mavis: You know why I say it's25% sir, because it says this means that half of the energy in the coal is lost as heat and light and other forms of energy.	**C**
Teacher: She doesn't agree with you.	
Gugu: It says 50% is input and then 50% is output and then now where does the 25% come from?	**R**
Mavis: Fom the energy in.	**C**
Teacher: Generally it's supposed to be input **Gugu:** 100%	**D**
Mary: Energy output 50% because energy output is always less than input energy and energy loss is 50%	**C/D**
What forms energy are wasted energy?	
Gugu: Heat and light energy.	**C**
Teacher: The other forms	
Class: like sound, kinetic	**D**
Suggest two ways in which energy could be used in a power station	

Mavis: Use the waste to heat the buildings or combine coal with other types of fuel such as natural gas.	**D**
What are green house gases?	
Nozi: Gases like carbon dioxide, sulphur dioxide released to the atmosphere add to the problem of climate change.	**D**
How do power stations impact on the environment? **Chris:** Coal pollutes the environment.	**C**

APPENDIX: 2a
LESSON TRANSCRIPTS 7-2

TRANSCRIPTION OF DATA	
NAME: T.MOYO	
CLASS: GRADE 7-2	
Topic: *Materials which are best insulators*	
Lesson 1 Group 3	
Small group discussion:	
Why must all containers used be identical?	
Senzo: For the experiment to be fair.	**C**
Ben: What do you mean when you say fair?	
Senzo: All the equipment must be the same so that the investigation can be right.	**C**
Ben: Please write this Eddie; All containers used should be identical so that the investigation is fair and accurate	
Why should the bottoms of the containers also be covered?	
Senzo: All the containers must be covered because heat can be lost under the container.	**R**
Ben: Why is that the bottom has to be covered because the top is not covered?	
Senzo: The top is not covered because we cannot where would we put the thermometer sit?	**C**
Ben: Will that make the investigation correct?	
Senzo: Yes because the rest of them are not covered.	**C**

Ben: But if you say that hmm the top are not covered because the rest of them are not covered, why should be the bottom be covered if we can make the rest of the bottom not covered?	**R**
Senzo: Because that's where the thermometer will come in.	
Ben: Hmm wait Senzo the last answer you gave is that the top must be open because the rest of them are open ok, why should the bottoms be covered if the rest of them are not covered? Why?	
Senzo: Because the glass is going to be put on top of another material, heat is going to be transferred from the glasses to the other materials.	**C/D**
Ben: Hmm it's gonna be put on top of other materials and heat can be lost I get it.	
Senzo: Yes because you can't hold the glass.	
Ben: The bottoms of the containers should also be covered because the glass should not be in contact with another material.	
Is it important that each of the containers had the same amount of hot water in it?	
Senzo: I think the glasses should have the glasses should have the same amount of water because it won't be a fair experiment if the water is cool or hot all of them should be the same.	**C/D**
Ben: I think it is important for the containers to have the same amount of water because when you are doing an investigation all the variables should be the same including the amount of water, temperature of water so that it can be effective.	**C/D/W**
Ben: It is important because when we want to have a fair test the variables should be the same.	

Whole class discussions	
Why must all containers used be identical?	
Ben: All containers used should be identical so that the investigation is fair and accurate.	**D**
Why should the bottoms of the containers also be covered?	
Luntu: The bottoms of the containers also need to be covered so that we get a actual temperature	**C**

Ben: If you are saying that the bottoms of the containers should be covered so that heat is not lost why should the top not be covered?	**R**
Senzo: So that heat is not lost to the table.	**D**
Ben: I think sir that if you put the cup on the table when it is not covered the table will also be hot.	
Senzo: Yes sir, I think heat will be transferred from the container to the table since the table will be a conductor.	**D**
Is it important that each of the containers had the same amount of hot water in it?	
Lu: Yestu sir because the bigger the amount of water is in the container the longer it takes for it to cool down but once the amounts are the same they will cool down immediately together.	**C/D**
Teacher: Yes there is a fact there although its mixed up in you statement that if you have different amounts of water in each of the containers your results won't be accurate one water in one container will cool faster than in the other container.	

APPENDIX: 2b

TRANSCRIPTION OF DATA	
NAME: T.MOYO	
CLASS: GRADE 7-2	
Topic: *Materials which are best insulators*	
Lesson 1 Group 4	
Small group discussion:	
Why must all containers used be identical?	
Why should the bottoms of the containers also be covered?	
Sphiwe: We said guys that the bottoms of the glass need to be covered so that the temperatures are the same..	**C**
Nkosi: I think so that we trying to support the width of the glass that's what I think	**C**
Is it important that each of the containers had the same amount of hot water in it?	
Luntu: I think we have to take it in different ways because the hotness of the water goes with amount of water.	**C**
Tom: I don't think it is important because we recording the temperature of water not the amount of water.	**C/C**
Luntu: But Tom if you put small ice it will melt quickly but if you put a bigger one it won't melt quickly.	**R**
Tom: Ok like let's focus on water when you pour like in each cup but the water is not equal I think it won't change anything man.	**C**

Sphiwe: I think it will.	**C/C**
Tom: No we not measuring the amount of water, we measuring the temperature.	**D**
Sphiwe: I also don't think it will coz you are measuring the temperature not the amount of water.	
Luntu: Ya now I get your point, because it's like when you put tea in two different cups the when you measure the temperatures will be same.	**D**
Tom: It's not like you put cold water in one cup and you put boiled water in another cup, you put boiled water in both cups so the temperature will be the same, so it isn't important.	**C/D**
Sphiwe: But then it says explain why this is so? It means that it is unfair	
Luntu: If the question had said that if yes explain and if no don't explain.	
Tom: So it is important.	
Luntu: Because it says explain why it is so then the answer is yes	
Sphiwe: The one that is small is gonna cool faster than the one that is full.	**C**
Tom: I think you are right: so we will say the smaller the amount of water the faster it will take to cool down and the bigger the amount of water in a container the longer it will take to cool down.	**D**
Whole class discussions	
Why must all containers used be identical?	
Ben: All containers used should be identical so that the investigation is fair and accurate.	**D**
Why should the bottoms of the containers also be covered?	
Luntu: The bottoms of the containers also need to be covered so that we get a actual temperature	**C**
Ben: If you are saying that the bottoms of the containers should be covered so that heat is not lost why should the top not be covered?	**R**
Senzo: So that heat is not lost to the table.	
Ben: I think sir that if you put the cup on the table when it is not covered the table will also be hot.	**D**

Senzo: Yes sir, I think heat will be transferred from the container to the table since the table will be a conductor.	**D**
Is it important that each of the containers had the same amount of hot water in it?	
Luntu: Yes sir because the bigger the amount of water is in the container the longer it takes for it to cool down but once the amounts are the same they will cool down immediately together.	**D**
Teacher: Yes there is a fact there although its mixed up in you statement that if you have different amounts of water in each of the containers your results won't be accurate one water in one container will cool faster than in the other container.	

APPENDIX: 2c

TRANSCRIPTION OF DATA	
NAME: T.MOYO	
CLASS: GRADE 7-2	
Topic: *Conservation of heat in homes and buildings*	
Lesson 2 Group 3	
Small group discussion:	
Which direction should a house face in this country?	
Senzo: It should face the north	**C**
Why should they face this way?	
Eddie: To gain heat, eh to become hot	**C**
What is the benefit of having a ceiling in the roof?	
Ben: I think ceiling traps air and this reduces the amount of heat that flows in the house.	**C/D**
How does the position of the sun change in winter and in summer?	
Senzo: Maybe we need to think about the position of the sun changes in summer and winter I don't know	

In the drawing of the energy efficient house shown in this lesson, list the features that you can see that are good design features.	
Ben: The roof of the house and the ceiling minimises heat loss that's why the house may be cooler in summer and warmer in winter.	**D**
Menzi: Cement, concrete bricks, building materials, the ceiling.	**C**
Some houses are cool in summer while others get hot inside in summer. Do you agree or disagree or disagree? Give reasons.	
Menzi: Umm they are all hot in summer	**C**
Ben: No its not true because some houses that are not built using insulating materials are hot inside in summer and cold during winter	**D**
Do you think indigenous houses are energy efficient? Explain your answer.	
Sizwe: Yes they are energy efficient.	**C**
Ben: did you check?	
Senzo: Yes	
Senzo: Like shacks are indigenous houses?	**C**
Ben: Do you know what an indigenous house is? A shack is not an indigenous house. This is because all the things that are used to build indigenous traditional houses use insulators like grass and wood.	**C/C+D**
Whole class discussion	
Which direction should houses face in the country?	
Nancy: The houses should face east.	**C**
Teacher: Do you agree with them?	
Class: No	
Tshidi: The houses should face north	**C**
Why should they face this way?	
Mfana: They should face this way so that they gain maximum heat from the sun.	**D**

What is the benefit of having a ceiling in the roof?	
Nancy: Ceiling traps air ensuring a reduction of heat into or out of the house.	**C/D**
How does the position of the sun change in winter and in summer?	
Luntu: In summer the sun is higher and in wither it is lower	**C**
In the drawing of the energy efficient house shown in this lesson, list the features that you can see that are good design features	
Mendy: The windows	**C**
Teacher: What can you say about the windows?	
Mfana: The windows have wooden frame so that are better insulators than metal frames Sir.	**D**
Teacher: What other factor?	
Mfana: The windows should be glazed with glass	**D**
Some houses are cool in summer while others get hot inside in summer. Do you agree or disagree or disagree? Give reasons.	
Ben: We agree because houses are made of different materials some houses are made of insulators and some are made of conductors.	**D**
Do you think indigenous houses are energy efficient? Explain your answer.	
Sphiwe: Yes sir, they are made of thatch and thatch is an insulator. Houses made of thatch are cooler in summer and warmer in winter.	**D/W**

APPENDIX: 2d

TRANSCRIPTION OF DATA	
NAME: T.MOYO	
CLASS: GRADE 7-2	
Topic: *Conservation of heat in homes and buildings*	
Lesson 2 Group 4	
Small group discussion:	
Which direction should a house face in this country?	
Nkosi: The house should face the north.	**C**
Why should they face this way?	
Luntu: They should face north to gain maximum heat from the sun and for effective solar collection	**D**
What is the benefit of having a ceiling in the roof?	
Tom: It's because it traps the heat inside the house.	**C**
Sphiwe: No**,** ceiling traps air ensuring reduction of heat and flow of heat in and out of the house	**D**
How does the position of the sun change in winter and in summer?	
Luntu: Ceiling traps air.	

Sphiwe: It doesn't say anything about the ceiling.	
Sphiwe: In summer the sun is much higher and in winter the sun is lower so this shades the house in summer when the sun is high.	**C**
Nkosi: Isn't air heavy than the sun	
Sphiwe: The question says; How does the position of the sun change in winter and in summer.	
In the drawing of the energy efficient house shown in this lesson, list the features that you can see that are good design features.	
Luntu: The ceiling, the carpets, the roof direction	**C**
Some houses are cool in summer while others get hot inside in summer. Do you agree or disagree or disagree? Give reasons.	
Sphiwe: I agree because houses have different materials. Because some houses are built of zinc and other houses of materials that are energy efficient.	**C/D**
Do you think indigenous houses are energy efficient? Explain your answer.	
Sphiwe: Yes because they are built from materials have properties that help them to be energy efficient.	**D**
Whole class discussion	
Which direction should houses face in the country?	
Nancy: The houses should face east.	**C**
Teacher: Do you agree with them?	
Class: No	
Tshidi: Th e houses should face north	**C**
Why should they face this way?	
Mfana: They should face this way so that they gain maximum heat from the sun.	**D**
What is the benefit of having a ceiling in the roof?	

Nancy: Ceiling traps air ensuring a reduction of heat into or out of the house.	**D**
How does the position of the sun change in winter and in summer?	
Luntu: In summer the sun is higher and in wither it is lower	**C**
In the drawing of the energy efficient house shown in this lesson, list the features that you can see that are good design features	
Mendy: The windows	**C**
Teacher: What can you say about the windows?	
Mfana: The windows have wooden frame so that are better insulators than metal frames Sir.	**C/D**
Teacher: What other factor?	
Mfana: The windows should be glazed with glass	**C**
Some houses are cool in summer while others get hot inside in summer. Do you agree or disagree or disagree? Give reasons.	
Ben: We agree because houses are made of different materials some houses are made of insulators and some are made of conductors.	**C/D**
Do you think indigenous houses are energy efficient? Explain your answer.	
Sphiwe: Yes sir, they are made of thatch and thatch is an insulator. Houses made of thatch are cooler in summer and warmer in winter.	**D/W**

APPENDIX: 2e

TRANSCRIPTION OF DATA	
NAME: T.MOYO	
CLASS: GRADE 7-2	
Topic: *Energy efficiency in power stations*	
Lesson 3 Group 3	
Small group discussion:	
Write three sentences to explain how a coal- fired power station makes electricity	
Ben: Coal is crushed, burnt, then water is boiled and steam is moved to the turbines and is turned into electricity, to the generators then supplied to people.	**D**
Senzo: No not to people but to the power stations.	**R**
Ben: No let us just say to people ”magents”	
Fill in the percentage of energy input, percentage loss and the percentage of the energy out for a power station. Also name the types of energy at each point.	
Senzo: 50% energy loss and 50% energy output	**D**
Ben: Wasted forms of energy sound, heat, kinetic	**D**
Ben: Sir, I have a question I don’t think the heat and kinetic energy is wasted energy because they are used to move coal from something to something when producing energy	**R**
Teacher: Can someone answer his question	
Senzo: Heat is already wasted because like there at the cooler towers that’s where the steam comes out which is heat right.	**D**
Ben: Sir when the process takes place the coal is moved from one place to another so that the process will take place.	
Teacher: I will not answer you I want you to ask the whole class during our feedback.	

Senzo: The coal mines are 50% efficient at best.	**D**
Ben: Energy input is 100%	**D**
What forms energy are wasted energy?	
Senzo: Sound energy, heat energy and light energy	**C**
Senzo: But how is kinetic energy wasted?	**C/C**
Suggest two ways in which energy could be used in a power station	
Senzo: It can be used by also adding natural gases **Ben:** By making the machines have less sound.	**D**
Senzo: But how?	
Senzo: Probably make them less louder?	
Ben: Make it a better machine.	**C**
Senzo: By using natural gases.	
What are green house gases?	
Ben: Carbon dioxide and sulphur.	**D**
Whole Class discussions	
What are greenhouse gases?	
Tom: Greenhouse gases are gases that trap heat in the atmosphere	**D**
Teacher: Somebody else	
Mfana: I think they are gases that pollute the air such as carbon dioxide and carbon monoxide	**D**
How do power stations impact on the environment?	
Mfana: They produce gases that are dangerous to the air like greenhouse gases which are carbon dioxide and sulphur.	**D**

APPENDIX: 2f

TRANSCRIPTION OF DATA	
NAME: T.MOYO	
CLASS: GRADE 7-2	
Topic: *Energy efficiency in power stations*	
Lesson 3 Group 4	
Small group discussion:	
Write three sentences to explain how a coal- fired power station makes electricity	
Nkosi: Coal is crushed, is heated to boil water changes to steam, steam drives turbines and the turbines drive the generator	**D**
Fill in the percentage of energy input, percentage loss and the percentage of the energy out for a power station. Also name the types of energy at each point.	
Sphiwe: Types of energy in the process: sound, heat, kinetic and light energy.	**D**
What forms of energy are wasted energy?	
Sphiwe: light energy, kinetic energy, sound energy when they are crushing coal	**C**
Tom: Also put heat energy	**C**
Sphiwe: Heat energy is not wasted, oh yes heat energy is wasted	**C/C**
Tom: How can heat be wasted when it is used to boil the water producing steam needed to drive turbines?	**D**
Nkosi: guys heat is wasted	

Sphiwe: It's needs the blaze	
Sphiwe: What is thermal energy?	
Tom: I have never heard this	
Suggest two ways in which energy could be used in a power station	
Sphiwe: One suggestion has been to use the waste to heat the buildings in the nearby district and they can combine coal with other types of fuel and to use waste matter from land sites fuels.	**D**
What are green house gases?	
Sphiwe: I think they are gases that pollute the air	**D**
Ithumeleng: Gravitational potential energy.	
Whole Class discussions	
What are greenhouse gases?	
Tom: Greenhouse gases are gases that trap heat in the atmosphere and reflecting it back and causing an increasing heat	**D**
Teacher: Somebody else	
Mfana: I think they are gases that pollute the air such as carbon dioxide and carbon monoxide	**D**
How do power stations impact on the environment?	
Mfana: They produce gases that are dangerous to the air like greenhouse gases which are carbon dioxide and sulphur.	**D**